POWER

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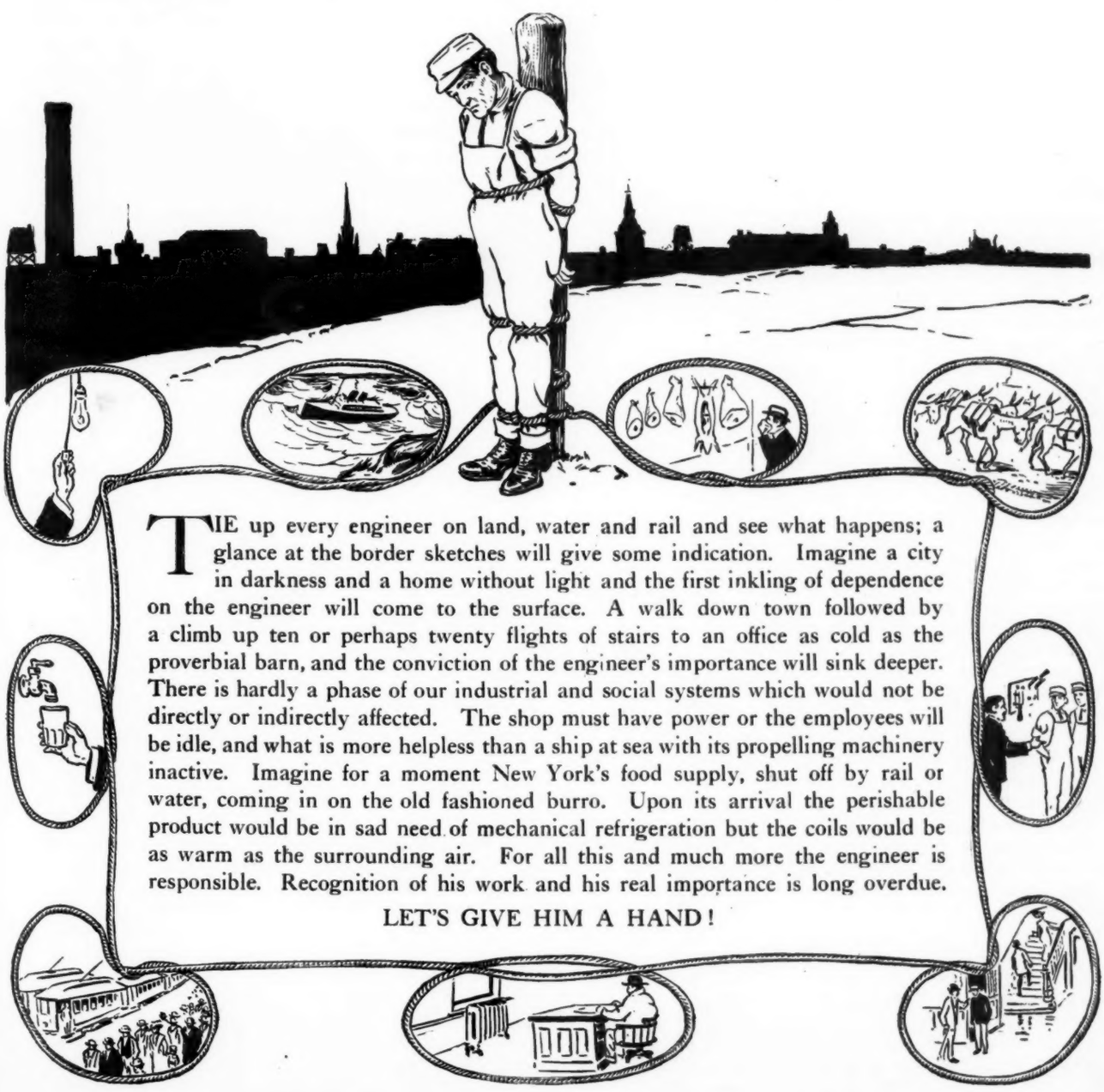
What Would We Do Without Him?



TIE up every engineer on land, water and rail and see what happens; a glance at the border sketches will give some indication. Imagine a city in darkness and a home without light and the first inkling of dependence on the engineer will come to the surface. A walk down town followed by a climb up ten or perhaps twenty flights of stairs to an office as cold as the proverbial barn, and the conviction of the engineer's importance will sink deeper. There is hardly a phase of our industrial and social systems which would not be directly or indirectly affected. The shop must have power or the employees will be idle, and what is more helpless than a ship at sea with its propelling machinery inactive. Imagine for a moment New York's food supply, shut off by rail or water, coming in on the old fashioned burro. Upon its arrival the perishable product would be in sad need of mechanical refrigeration but the coils would be as warm as the surrounding air. For all this and much more the engineer is responsible. Recognition of his work and his real importance is long overdue.

LET'S GIVE HIM A HAND!

The Eyermann Steam Turbine

By Wilhelm H. Eyermann*

A description by the inventor of a radial-flow steam turbine which has been built in capacities up to 2400 kw.

The constructional difficulties incident to the type are pointed out and the methods of overcoming them described.

*Translated in abstract from "Kraftmaschinenbau," by E. P. Buffet.

The fact that, in spite of some marked advantages in principle for the radial type of turbine over the axial type, the axial has so far outstripped its rival may be ascribed to constructive difficulties in the radial design and to a belief that it is impossible to get the necessary number of rows of blades on one or two wheels.

Naturally, the rotor and guide blades of a radial turbine must be dismounted axially. This is readily possible with one or two wheels, but difficult with more. It is, therefore, a vital condition with the radial turbine that the number of blade rows be comparatively small. This is possible when the pressure drop in the first stage is made quite large, say from 12 to 2 atmospheres absolute pressure, the arising velocity-energy being transformed in one or two rows of rotor blades and the remainder of the head utilized in a small number of pairs of blade rings working upon the impulse system.

In the year 1904, when the author worked out his turbine system, there were customary for impulse turbines 15 to 30 and for reaction turbines of high speed 50 to 120 pressure stages. The consideration that the lost work of the steam in leakage through the clearance between the blade rims must constitute a large portion of the total losses induced the author to make an experiment with a few stages and comparatively high steam velocities. Such a turbine of 250 hp. gave a Rankine efficiency of 54.4 per cent., a good result considering the date and the experimental construction.

On the ground of what was then learned, there was built a 1200-hp. turbine which in 1909 was tested in the mechanical laboratory of the Charlottenburg Technical High School. A section of this turbine is given in Fig. 1. The operation is as follows: After the steam has successively passed the stop valve, quick-closing valve and governor valve, it enters through a side connecting branch into the cast-steel ring *a*, expands in the nozzle *b* to about 1.5 atmospheres absolute, imparts its velocity to two rotor-blade rings and then expands in five further pairs of guide and rotor-blade rims to the condenser pressure. The entire transformation of energy takes place almost in one plane in a very short and simple way. The rotor is carried upon the end of the shaft without an outer bearing rendering a stuffing-box unnecessary.

The design of the rotor presents two main difficulties: first, through the bending forces due to one-sided admission, which tends to cause unsymmetrical steam pressure, and, second, an eccentric pull by the centrifugal force of the blades. It would not be impossible to build the rotor strong enough to keep its flexure within limits; but the advantage of lightness would thus be lost. In the accompanying design the axial pressure of the live steam is balanced by opposing on the back side of the wheel a steam pressure of suitable magnitude. For this purpose, the back side of the wheel opposite to the blade rims is provided with labyrinth grooves which hold the steam in the chamber *c* from passing into the chamber *d*. The steam pressure in the chamber *c* is maintained at the proper degree by the passage of the requisite quantity of steam from the chamber *e* into the chamber *c* through the passage *f* between the wheel and the body of the stuffing-box and through holes in the wheel disk. If the pressure on the labyrinth side is too low, the disk moves to the left by a small fraction of a millimeter and opens the crack *f* wider, letting more steam pass through it into *c*, whereby the pressure rises and the shifting movement comes to rest at the proper distance to maintain a balanced pressure. This displacement necessary for pressure regulation amounts, within the widest practical limits of pressure and temperature, to hardly 0.004 in. That this exceedingly small axial movement suffices is explained by the fact that the expansion of the steam in the blading, in the throttling passage and in the labyrinth, proceeds according to almost the same law and, therefore, the pressure and volume of the steam in all parts of the turbine vary in nearly proportional amounts. This arrangement insures that, even when the turbine is under a light load, the correct axial adjustment takes place with great positiveness, but if very little or no steam be supplied to the turbine, and therefore no considerable axial pressure be exerted, it naturally does not work. The disk must therefore be insured against striking in this case. This is effected by a collar *g* which is placed in the bearing with an axial play of about 0.04 in. In normal service, however, these guide surfaces do not touch.

The eccentric centrifugal force of the blades is balanced by sector-shaped counterweights placed on the back side of the disk. The outer surface of the

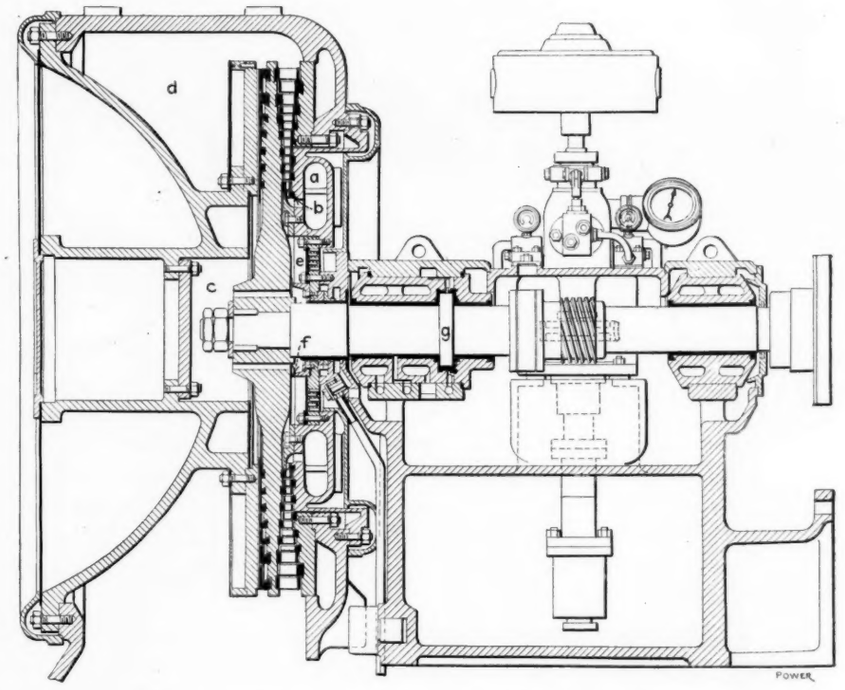


FIG. 1. EYERMANN 1200-HP. TURBINE TESTED IN 1909

counterweight carries the aforementioned labyrinth grooves whose form is shown in Fig. 2. This labyrinth form has been worked out experimentally so as to have a strong throttling effect, which may be explained by the fact that in the space between two clearances is produced a regular vortex which causes a great con-

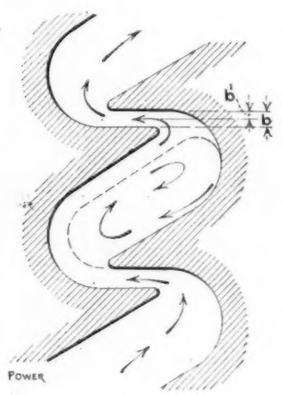


FIG. 2. LABYRINTH PACKING

traction of the area available for steam flow, as the drawing shows. The cross-section b of the passage is made as narrow as permissible with respect to precision of manufacture and unavoidable changes of shape in order to keep the steam quantity down as small as possible. This smallest dimension amounts, according to the conditions, to from 0.012 to 0.08 in. The rounded shape of the vortex chamber causes the whirling steam

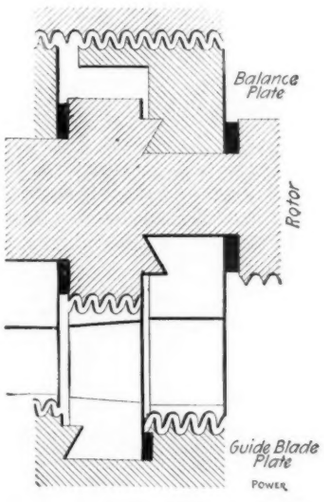


FIG. 3. BLADING

current to sweep by the point of outlet b with considerable velocity; the outflowing steam splits off from this vortex and, by reason of its momentum, presses against one wall of the outflow cross-section, so that only the width b is available for the flow while the remainder of b is filled out by an eddy. Only the width b' is to be considered as the effective cross-section of the orifice, while in actual construction the space b may be made about 50 per cent. wider than b'.

The blades are milled from the solid, nickel steel or special bronze being used according to the service. They are fastened by setting the half dovetail-shaped blade foot into a corresponding groove of the disk and securing by calking as shown in Fig. 3. The shrouding is riveted on, either in one piece with the blade, or in sectors. For the low-pressure stages it is provided with labyrinth grooves like those of the counterweight. These grooves are turned in the already bladed wheel-disk or guide-blade plate, and the fastening of the blade has thus to stand a sharp test of its security. The shaft rests in two bearings between which are placed the worm for driving the governor and oil-pump shaft and the safety governor.

The regulation is controlled indirectly by means of an oil servomotor. Fig. 1 shows, above the worm, the control valve operated by the governor for the adjustment of the regulating valve. This valve is, on normal turbines, a double-seated one and works by throttling. At the lower end of the governor shaft is a screw pump for furnishing oil under pressure to the bearing and the regulating mechanism. The governor shaft, together with its bearing and the pump, can, after loosening the oil connections, be easily taken out.

The casing is in one piece and is so placed upon the frame that it can freely expand both radially and axially, while remaining true with respect to the plane of the wheel center and to the axis. The dismounting is performed axially. The cover and wheel can be taken off in ten minutes by means of a special tool, which leaves all the inner parts of the turbine accessible for inspection.

In order to adapt the foregoing model and elements of construction to low-pressure, back-pressure and exhaust-steam turbines, the high- and low-pressure stages are divided between two separate wheels. This gives a somewhat better efficiency of the high-pressure wheel, since it may be made larger in diameter. The first turbine built in this way, running at 3000 r.p.m. with a load of 1200 kw., 12.35 atmospheres absolute initial pressure and 331 deg. C. (628 deg. F.) before the stop valve and 0.025 atmos-

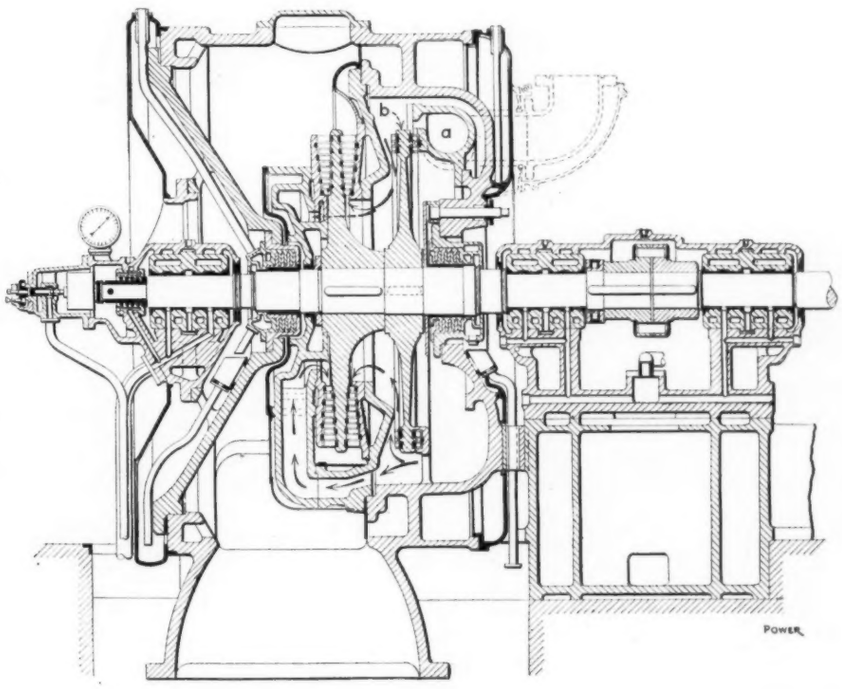


FIG. 4. COMBINED VELOCITY- AND PRESSURE-STAGE TURBINE 2400 H.P.

phere condenser pressure, ran upon 6.3 kg. (13.861 lb.) of steam per kilowatt-hour.

The turbines hitherto built have been constructed, according to existing ideas, with the smallest possible number of stages, that is, approximating as closely as possible to the critical steam velocity. Experiments in the mechanical laboratory of the Technical High School at Charlottenburg have indicated, however, that this steam velocity may advantageously be exceeded, so that it may be possible still further to decrease the number of stages. Consequently, for a speed of 3000 or of 1500 r.p.m., one may get as the full limit of power under normal conditions, with steam admitted on one side, 1700 or 4500 hp., and with admission on both sides, 3500 or 9000 hp. The dimensions of machines so constructed are shown in Figs. 5 and 6.

For these turbines, as well as for that in Fig. 4, a new method of regulation is employed. The governor is seated on the free end of the shaft, and offers to the passage of the oil a different section of orifice for each speed. This oil operates a servomotor which controls the throttle regulating valve. The oil pump is here driven, not from the turbine shaft but by a special electric or steam drive, which method leads to a considerable simplification and cheapening of the construction.

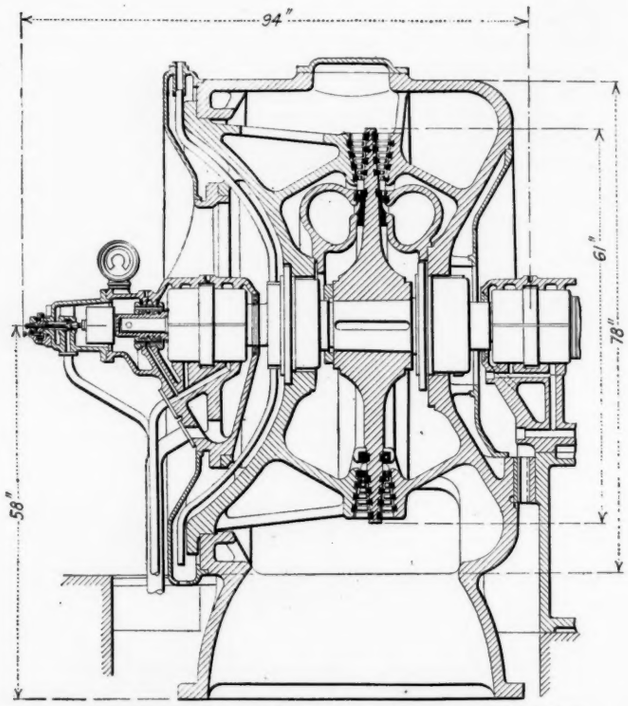


FIG. 5. 3500-HP. 3000-R.P.M. EYERMANN TURBINES

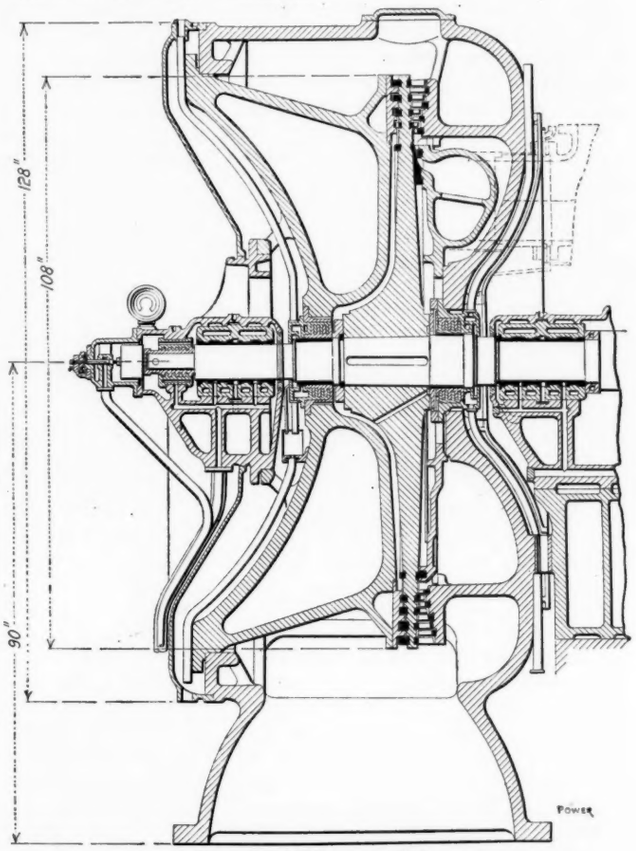


FIG. 6. 4500-HP. 1500-R.P.M.

The New Allis-Chalmers Engine

Description of the construction of a new Corliss engine built by the Allis-Chalmers Co., and table of tests. Among the interesting details are the valves, especially adapted for high temperatures, the piston construction and the governor.

The Allis-Chalmers Co., Milwaukee, Wis., has recently brought out a new Corliss engine, which has many attractive features. It is not an old design fixed up, but an entirely new machine. The frame is in one piece of massive design, the outside being a smooth casting, Fig. 1, which is easy to keep clean. A lip cast around the base of the frame catches any oil that may get outside, but very little can do so on account of the arrangement of oil guards, to which particular attention has been given.

The crank oil guard entirely incloses the crank and has a rectangular opening in front with two large doors, as shown in Fig. 2, the panels of which are wire screens, permitting air circulation to keep the internal parts cool and prevent oil being thrown out. The doors are large enough so that the crank brasses can be keyed up without taking off anything, and by removing four small bolts on the bar to which the doors are hinged, the doors can be removed, and the opening is large enough to permit the brasses to be taken off from the pins without taking off the oil guard.

The frame has unusually heavy jaws to carry the shells, which inclose the main bearing. The bottom shell is spherical, resting in a recess of the same form in the bedplate, which design allows the shells to align themselves with the shaft under all conditions. To remove the bottom shell requires only lifting the shaft about $\frac{1}{32}$ in. when the bottom shell can be rolled out. The quarter boxes are both adjustable with a wedge running the entire length, and each wedge has two draw bolts and two setscrews, so that the wedge can be positively held in any position desired.

The cylinder, shown in section in Fig.

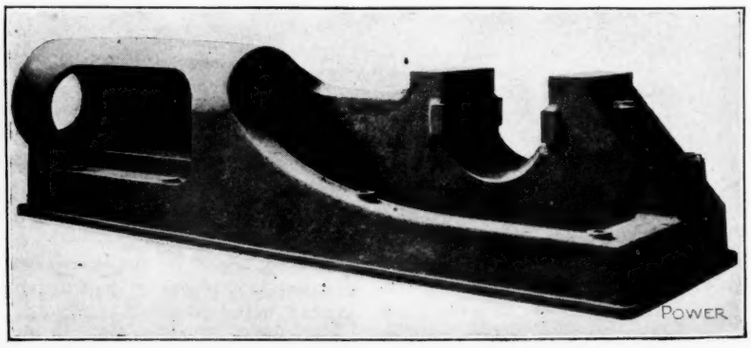


FIG. 1. FRAME OF THE NEW ALLIS-CHALMERS CORLISS ENGINE

3, has been designed with the smallest clearance consistent with getting the steam into and out of the cylinder, with the least possible losses. The steam valves are of the three-bar type, which design allows the valve to retain its form and remain tight, with very high temperatures due to high steam pressure and superheat. The center of the exhaust-

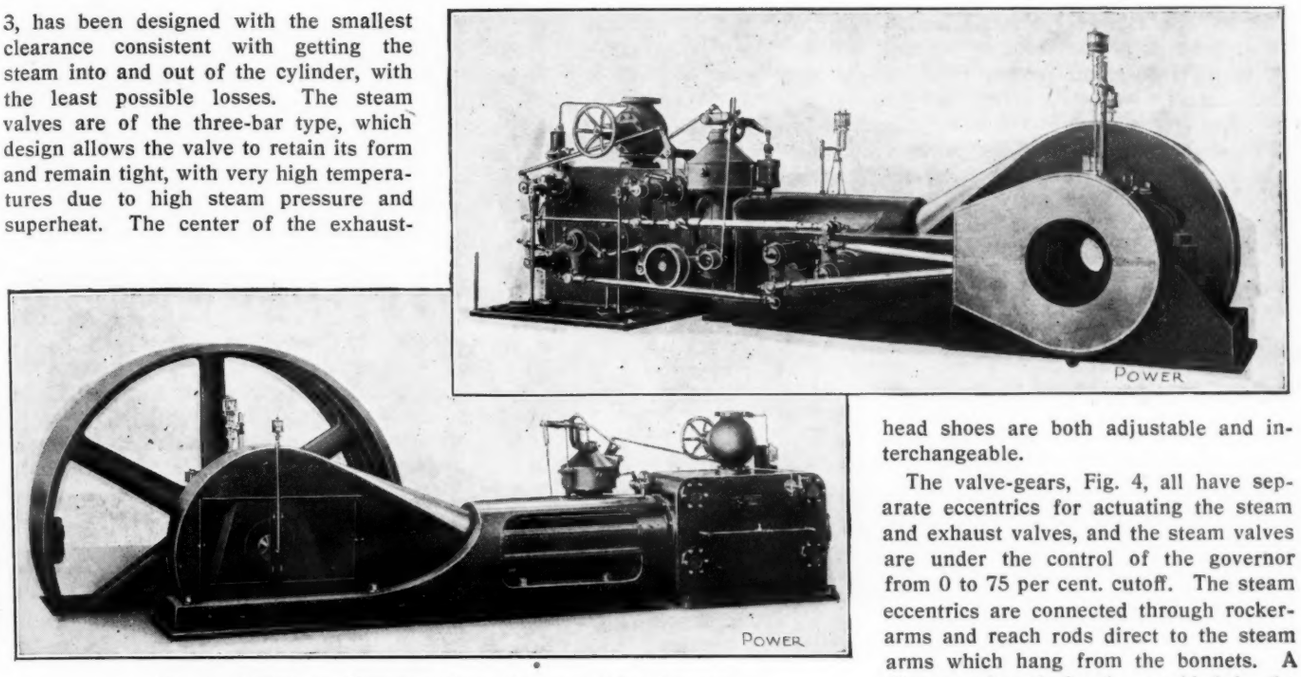


FIG. 2. VIEWS OF OPPOSITE SIDES OF THE NEW ENGINE

valve chamber is on a line with the bottom of the cylinder, and is so placed that the piston does not travel into the valve chamber. This design reduces the clearance as much as it can be with certainty that the piston will never under any condition strike the valve. All valves are multi-ported with a short travel.

The piston is made wide, giving a broad wearing surface and has two rings, which travel over the counterbore, so that no shoulders will be worn at the end of the cylinder. Fig. 5 is a section of the piston showing particularly the method adopted to prevent the follower nut from falling into the cylinder if a stud bolt breaks. The safety collar is larger than the opening in the follower for the head of the bolt, so that if the stud breaks off in the threads the broken-off portion with the nut cannot fall out.

The piston rod is forged with a large collar, and the end of the rod has a nut for securing it to the piston. The other end of the rod screws into the crosshead and is held with a locknut. The cross-head shoes are both adjustable and interchangeable.

The valve-gears, Fig. 4, all have separate eccentrics for actuating the steam and exhaust valves, and the steam valves are under the control of the governor from 0 to 75 per cent. cutoff. The steam eccentrics are connected through rocker-arms and reach rods direct to the steam arms which hang from the bonnets. A disconnecting device is provided in the

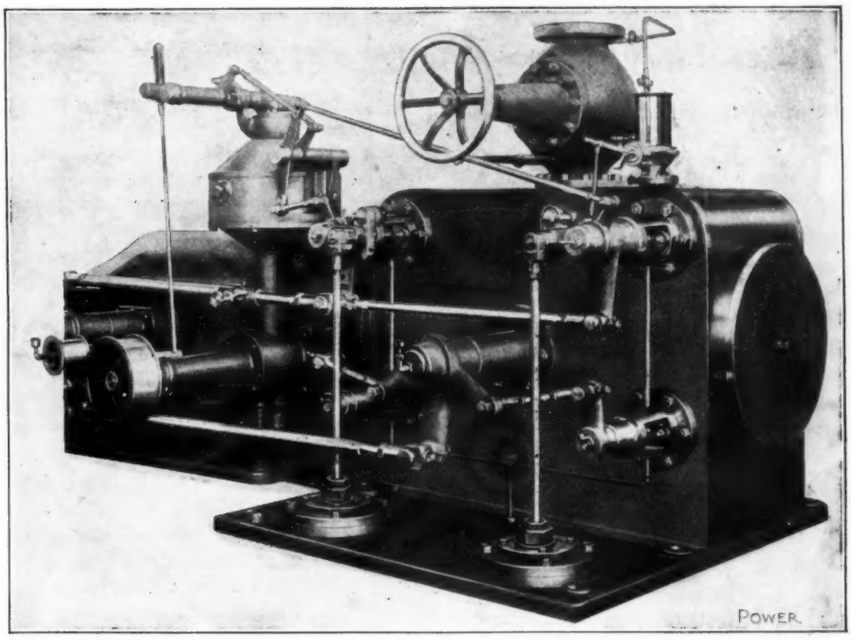


FIG. 4. DETAIL OF THE VALVE-GEAR

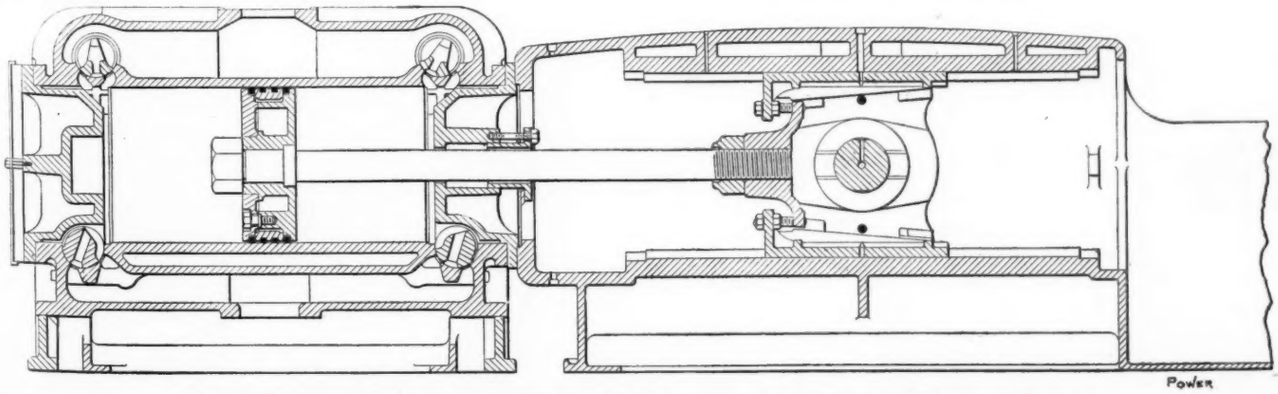


FIG. 3. VERTICAL LONGITUDINAL SECTION THROUGH THE CYLINDER AND CROSSHEAD GUIDE

reach rod from the rocker to the crank-end steam arm, and is arranged so that one part of the rod telescopes into the other. A center pin with a spring (shown just below the governor in Fig. 4) on the outer part, when released engages the hole in the near rod and the clamping device is then screwed up, which locks

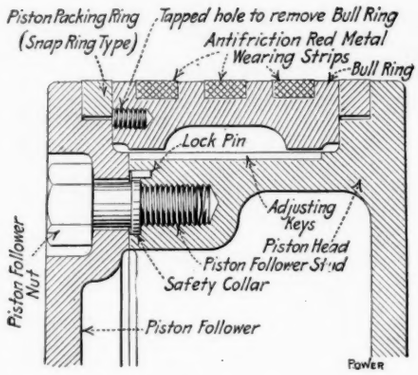


FIG. 5. DETAIL SECTION OF THE PISTON

the two parts of the rod solidly together, precluding lost motion in the disconnecting device. The exhaust valves are actuated through a wristplate, which gives the quick opening and closing movement necessary to properly operate the exhaust valves on a Corliss engine.

One of the most striking features on this new engine is the governor, which is a radical departure, and has proved so satisfactory in its operation, that the

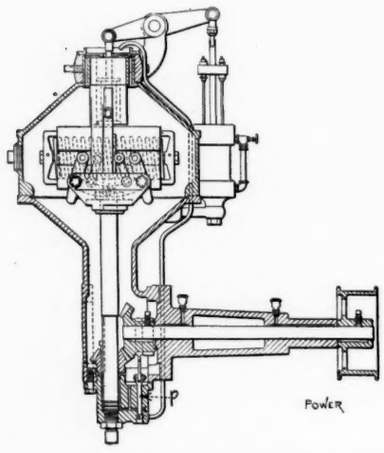


FIG. 6. SECTIONAL ELEVATION OF THE GOVERNOR

Allis-Chalmers Co. has adopted it, and is using it on all steam and gas engines, also steam and hydraulic turbines. Its external appearance is shown in Fig. 5 while Fig. 6 shows it in section. All of the moving parts are inclosed in a cast-iron case which prevents the throwing of oil around the engine room, and, what is more serious, into the generator of direct-connected machines with the serious result of oil-rotting the insula-

TESTS OF ALLIS-CHALMERS TYPE H 20X36 IN. SIMPLE CORLISS ENGINE

Date of test	Steam Pressure 100 lb. Gage Condensing and 120 lb. Gage Non-Condensing	Steam Pressure 80 lb. Gage						Steam Pressure 100 lb. Gage						Steam Pressure 120 lb. Gage						Steam Pressure 100 lb. Gage Condensing and 120 lb. Gage Non-Condensing		Steam Pressure 100 lb. Gage		
	11–11–10	11–14–10	11–15–10	11–16–10	11–16–10	11–17–10	11–17–10	11–17–10	11–21–10	11–22–10	11–23–10	11–23–10	11–25–10	11–25–10	11–28–10	11–29–10	12–21–10	12–21–10
Approximate load	Full	Full	1¼	½	¾	¼	¼	Full	Full	Full	½	1¼	¼	¾	Full	¾	1¼	¾
Duration, hr.	2	2	2	1	1	1	1	3	3	3	1	2	1	2	2	2	2	3
Steam pressure at throttle, lb. gage	100.33	82.56	80	81	80.6	81.71	100.71	100	119.6	119	119.2	120	119.3	120	121.1	119.34	99.78	100
Steam temperature in calorimeter, deg.F.	275	272	275	262.14	269.5	258.6	264.1	274.6	277.3	277.3	277.2	273.89	269.4	273.89	275.2	271.56	273.9	268.85
Exhaust pressure at cylinder, lb. abs.	4.2	13.62	13.72	13.32	13.38	13.38	13.38	13.57	13.35	13.35	13.3	13.61	12.8	13.03	22.2	22.2	13.75	13.44
Revolutions per minute	120.67	120.96	121.89	120.08	120.58	121.08	120.92	120.8	120.58	120.87	120.77	121.32	120.64	121.02	120.43	120.18	120.06
Total steam per hr. (corrected for condenser leakage) lb.	7395	6299	8138	3763	4958	2884	3108	7176	7778	4010	9996	3001	5712	8256	6163	9860	5269
Quality of steam, per cent. dry	99	99.4	99.6	98.8	99.25	98.6	98.5	99	98.8	98.8	98.8	98.3	98.5	98.6	98.5	99.3	98.7
Total dry steam per hr., lb.	7320	6260	8100	3720	4920	2844	3061	7104	7685	3962	9875	2950	5626	8141	6071	9785	5200
M.E.P. head end lb.	54.22	39.85	48.39	20.77	30.76	12.2	14.91	48.43	53.96	25.19	67.85	15.8	40.43	52.29	38.03	62.81	35.61
M.E.P. crank end lb.	58.44	40.53	48.9	23.98	32.38	15.22	20.15	49.02	55.93	31.36	68.97	21.27	43.35	53.77	39.72	63.46	37.21
Total I.H.P., lb.	381.3	272.6	332.2	150.4	213.2	92.85	118.4	329.7	371.3	191	462.8	125.6	282.6	359	261.9	425.1	244.7
Dry steam per I.H.P. (actual as per test), lb.	19.2	22.95	24.35	24.73	23.1	30.6	25.86	21.56	20.7	20.74	21.32	23.48	19.9	22.68	23.17	23	21.21
Dry steam per I.H.P. (back pressure reduced to 16 lb. abs.) lb.	.....	24.85	26.23	27.2	25.14	33.6	27.65	23.18	22.3	22.2	22.77	25.55	21.63	.....	.....	24.6	23
Kw. output (by integrating wattmeter)	264.2	174.6	218.8	88.3	130.8	43.83	62	213	244	116.6	310	71.7	180	237.5	167.1	283	152.2
Dry steam per Kw. (actual as per test) lb.	27.73	35.83	37	42.13	37.6	64.9	49.4	33.4	31.5	33.95	31.85	41.15	31.25	34.28	36.3	34.57	34.13
Dry steam per Kw. (back pressure reduced to 16 lb. abs.) lb.	.....	38.80	39.84	46.35	41	71.3	52.8	35.86	33.95	36.35	34	44.77	33.96	.....	.....	36.96	36.95
Mechanical efficiency per cent.	.....	89.9	92.2	84.6	86.9	74.4	77	90.4	92	86.8	93.75	83.6	89.3	92.5	89.5	93.1	87.4
Friction HP.	.....	27.8	20.2	23.2	28.2	23.75	27.2	31.7	30.3	25.1	29.8	20.6	30.3	26.8	27.5	29.1	30.9
Thermodynamic efficiency (based on I.H.P.) per cent.	58.5	77.4	74.7	72	77.5	57.8	63.6	75.8	73.3	73.6	71.8	63.8	75.3	82	81.5	71.5	76.2

tion. This governor is of the single-tension spring type, extremely powerful and sensitive in its operation, and so arranged that a stream of oil is automatically delivered by the little pump *p*, Fig. 6, into the top of the case, keeping all moving parts of the governor flooded.

Within a few months, this type of governor has been installed on seventeen 10,000-hp. engines in the Seventy-fourth St. and Fifty-ninth St. power stations of the Interborough Rapid Transit Co., replacing the old weighted fly-ball governors. The regulation obtained with the new governor is so much better that the expense of making the change was justified, although the old type of governor was considered good enough to have remained in use for the past eight or ten years.

The accompanying table gives some test results from a 20x36 simple engine under different conditions of load and pressure, condensing and noncondensing.

Flue Gas Analysis for Beginners—III

By J. E. Terman

Collecting an average sample from the boiler, the apparatus for doing it and full directions for carrying on the work.

Orsat totals as a check on the analysis.

In any test, carefulness with each part contributes to accuracy in the final result, but generally one or more main features are more important than the others. Thus, in a boiler test, pressures are to be noted, temperatures read, ashes weighed and numerous other records carefully kept, but above all, the amount of water evaporated and the number of pounds of coal burned to produce this evaporation must be accurately ascertained.

The most important feature in flue-gas analysis is obtaining a correct average sample of the gas. The appendix to the code of "Steam Boiler Trials," by J. C. Hoadley, page 287 of Volume 6 of the *Transactions* of the American Society of Mechanical Engineers, advises having an orifice through which the sample is drawn for each 25 sq.in. of the cross-section of the flue, principally because it collects samples of equivalent composition when located at two different points in a flue.

The samples collected are not necessarily average samples of the gas passing through the flue; possibly are not as good average samples as may be collected through a single sample tube properly located in the flue.

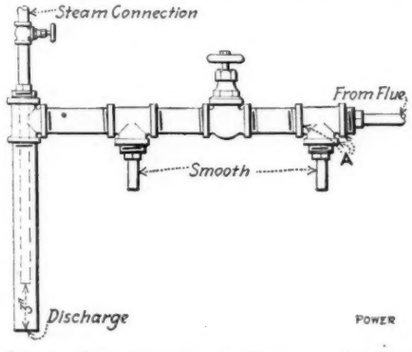


FIG. 1. APPARATUS FOR DRAWING SAMPLE FROM FLUE

If all of the cross-sectional area of the flue was occupied by the products of combustion moving at a uniform velocity, an arrangement such as was recommended by Mr. Hoadley would be all right. As an actual fact, however, the velocities vary widely at different points in a flue, and at some points the flue is carrying only air leakage from the outside. Evidently, under such conditions, a sampler which draws an equal volume from all parts of the cross-section of a flue in a given time, does not obtain an average sample of the gases passing through it.

Suppose a flue carries O and CO_2, both gases entirely separated, each occupying exactly one-half of the area of the flue and the CO_2 moving twice as fast as the O. A true sample of the gas passing through the flue would contain two volumes of CO_2 to one of O, but a sampler that would draw an equal volume from each square inch of the cross-sectional area of the flue would show equal volumes of O and CO_2. The actual variations in velocity greatly exceed those just assumed, and the gases are not of uniform composition. Other disadvantages of the sampler just described are its high cost and its being difficult to install.

Usually sampling is done by drawing the sample through a single tube with the end open and usually perforated part of its length. The tube should have its open end at that part of the flue where the gases move the swiftest, for a sample taken here is most nearly a true average one. To eliminate the effects of air leakage through the setting, the tube is often placed immediately adjacent to the furnace, but sampling here being difficult, due to high temperatures, the writer would advise the beginner to be satisfied with a sample taken at the nearest available point after the gases leave the boiler.

Where the gases are moving fastest can usually be found by looking for the path of probable least resistance, usually the shortest path, and where gas may be deflected, or made to eddy, by noticing the shape of the flue connection. A few tests of samples drawn while a uniform fire is maintained, with the sample pipe moved to different points in about the location judged to be right, will usually determine the correct point by the higher CO_2 content in the gas. Another way to locate the proper point for sampling is to measure the temperature of the gases and place the end of the sample pipe at the hottest point.

ASPIRATOR

Several different means may be used to collect the gas sample, but the writer considers the one about to be described the best that has come to his notice. The sample to be analyzed should be taken from a large quantity drawn in a steady stream from the flue. To get it a draft must be produced considerably in excess of that caused by the stack. An aspirator to produce this draft, which may be operated by steam, water or compressed air, is shown in Fig. 1. This can be made of ¾-in. and ¼-in. pipe.

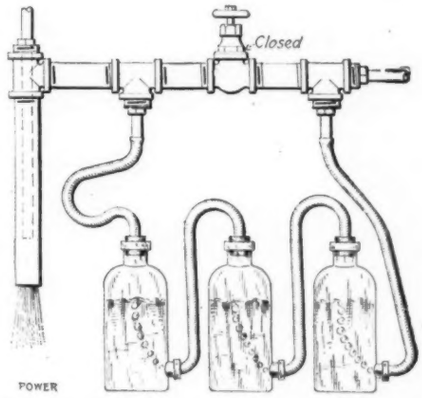


FIG. 2. SATURATING WATER WITH FLUE GAS

The discharge end should be about 8 or 10 in. long and the internal steam pipe should be about 3 in. shorter than the outer pipe. The tees shown should be connected together by short nipples. The two ¼-in. nipples projecting downward from the horizontal tees should be about 2 in. long and ground, or filed smooth on the outside so that pieces of rubber tubing may be slipped over them easily. The valve between the tees may be either globe or gate. A valve regulates the flow of steam and the amount of draft produced.

The joints *A* and all the joints on the pipe leading from the flue, must be perfectly tight to prevent an inflow of air from affecting the sample. Fig. 2 indicates how a draft is produced by the outrush of steam, causing a partial vacuum in the vertical pipe above the discharge nozzle. The vacuum causes a flow of gas in the pipe from the flue when the valve is open and the two outlets below the horizontal tees are closed.

Bottles for Collecting Samples

Some kind of portable container to collect the gas to be analyzed is required. For this and for saturating water with

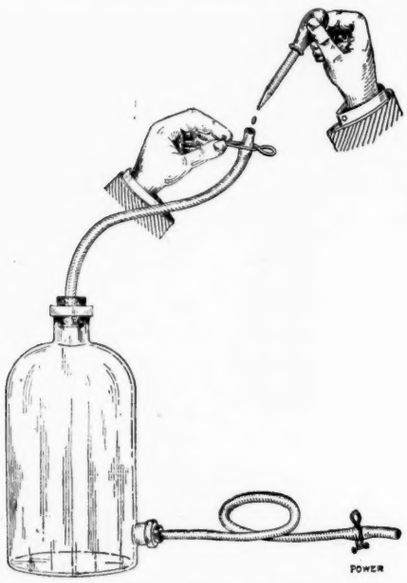


Fig. 3. Completing the Filling with a Dropper

the flue gas, the writer has found a double-necked bottle, such as is shown in Fig. 2, very convenient. Short lengths of glass tubing inserted through holes cut in rubber stoppers are convenient for attaching the rubber tubing. Stoppers can be easily made from round gasket stock of suitable diameter. The rubber tubes attached to the bottom connections should be the same length on all bottles, as this length determines the head of water tending to cause a flow from the bottle while collecting the sample.

The pinch-cocks on the rubber tubing serve to stop the flow of gas or water when desired. They should be as near the ends of the tubes as possible, to avoid air pockets when making connections with other apparatus. Many recommend using pinch-cocks to regulate the flow of water from the sampling bottle, and consequently the amount of the sample collected in a given time, counting the drops of water to judge the rapidity of flow. After numerous attempts to follow this advice without very good results, the writer adopted the following method:

While taking a sample for a given time the flow of gas into the sample receptacle should be uniform. The composition of gas in a flue is constantly changing, and if the rate of flow of water from the sample bottle varies, the resulting sample will not be a true average. To obtain a predetermined rate of flow, the writer took pieces of glass tubing about 2½ in. long, and heated one end in a bunsen burner until it was nearly closed. A number of these tubes with openings of various diameters were tested for flow by connecting them to the bottom of a sampling bottle filled with water. Each was marked with the number of minutes it took to empty the bottle of two-thirds of its contents, this representing a good quantity for a gas sample when using the size bottles adopted.

To take a continuous sample of flue gas to be analyzed at 30-min. periods, a 30-min. tube would be selected. The manipulator could then open the pinch-cock on the rubber tube and without further attention to it, be certain that in 30 min. he would have the correct quantity of gas for a sample. Fig. 4 shows one of these tubes at *B*.

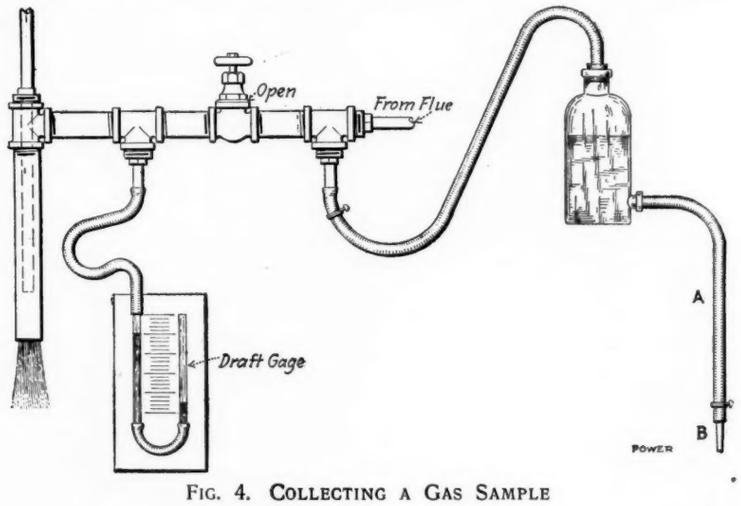


Fig. 4. Collecting a Gas Sample

Liquid Over Which Sample is Collected

To collect a gas sample, the bottle is first filled with some liquid to be displaced as the gas collects. Mercury, oil, water and other liquids have been used, but for ease of handling and cheapness, water is to be preferred by the beginner and generally by the experienced operator, when certain precautions are taken. If a sample remains long in contact with water, some of the CO_2 content will be absorbed. Therefore, to get accurate results, the water should first be saturated with the gas to be analyzed.

This can be done by using the valve on the horizontal pipe shown in Fig. 1. Several sample bottles are connected together and to the two outlets, as shown in Fig. 2, and the ¾-in. valve closed; steam is then turned on the aspirator until gas begins to bubble up through the water. Quite a draft will be required if three or four bottles are used, because the head to be overcome is the combined depth of water in all of the bottles. Complete saturation of the water will take about 30 min.

Collecting the Sample

The bottle in which a sample is to be collected and all the rubber tubing in its connections should be completely filled with the saturated water. A medicine dropper is convenient to complete the filling of the tubing, used as illustrated in Fig. 3. This done, the bottle is attached to the sampling apparatus, as in Fig. 4. It should be on the side of the valve nearest the flue, so that air leakage through the packing gland, or other joints, will not affect the sample.

The draft gage, although not essential, is convenient to use in sampling because it enables obtaining uniform draft conditions. Varying the amount of draft while collecting a sample will have the same effect as varying the length of the tube *A*. The draft gage gives a positive indication of a substantial flow of gas through the pipe from which the sample is being drawn.

After the bottle is connected, the aspirator is started, the ¾-in. valve on the horizontal pipe being opened and the steam flow adjusted until there is 4 or 5 in. of draft on the sample pipe. After making these adjustments, a short time should elapse for all air in the pipes to be removed, then both pinch-cocks on the connecting tubes are opened. Care should be taken to have the tube *B* for regulating the flow of water, inserted in the bottom connection. To remove the sample from connection with the aspirator, always close the pinch-cocks first. While collecting a sample, the saturated waste water from *B* should be caught in

another bottle, or receptacle, so that it may be used over again.

Orsat Totals

A beginner knowing little about chemistry is likely to make the mistake of assuming that as long as he follows the directions the results are bound to be correct. He should be always on the lookout for mistakes when he obtains strange or unexpected results in analyses, and not conclude too hastily that something is radically wrong with the furnace or the firing methods until he is certain that the sample represents the average of the products of combustion and was correctly analyzed.

A fairly reliable check on an analysis is to add the total of the CO_2, O and

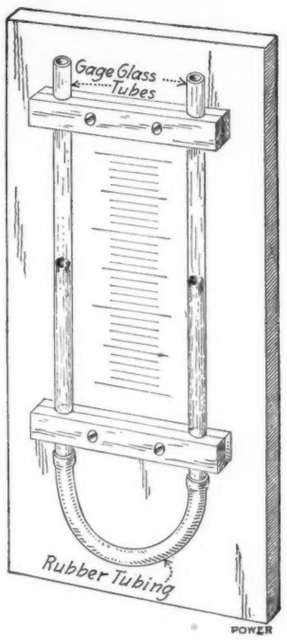


Fig. 5. Draft Gage

CO, as found for each analysis, or the Orsat totals, as they are called. But for the presence in the flue gas of small quantities of other gases besides CO_2, O, CO and N, the Orsat totals for each analysis would be about 21 per cent. or more; instead the totals rarely reach this amount, especially right after firing fresh fuel. However, they should very seldom be below 18.5 per cent., unless the sample is taken during a very short interval of time immediately after firing.

A great many analyses of flue-gas samples were made for the boiler division of the United States Geological Survey at the fuel-testing plant at St. Louis during 1904, 1905 and 1906. Out of 270 such tests, as reported in "A Study of Four Hundred Steaming Tests," the average Orsat totals were 19.17 per cent. with a minimum of 18.45 and a maximum of 20.07. These tests were made by expert chemists, and the figures obtained may be considered representative for such work. If the Orsat totals are less than 18.5 per cent., another portion of the gas sample should be analyzed with the greatest care, so as to be certain of results. The chief cause of incorrect analyses is haste to complete the operation. At least 20 to 30 min. with skillful handling is required with the apparatus described here, and the beginner should take longer until he becomes accustomed to the work.

Testing Furnace Conditions

With draft conditions uniform and the fuel evenly distributed over the grates, a certain thickness of fire for each kind of coal will give the best results. After this has been determined the boiler attendants can tell fairly well by the condition of the fire whether the fuel is being economically burned. To determine the proper thickness of the fuel bed, a boiler should be run for two or three hours with the fire of the thickness to be tested, and a continuous sample of the flue gas taken and analyzed at half-hour periods. Records should be made of the results obtained, and different thicknesses tried in the same manner. The thickness of the fire should be changed about 2 in. at a time until it reaches a thickness where the lack of draft, or other conditions, render its further increase impracticable.

After all tests have been made, it is well to repeat them before trying to deduce conclusions. Then, if the analyses show approximately the same results, it is fairly safe to assume that the samples are representative ones for the furnace and fuel tested and a decision can be made as to the thickness of fire producing the best combustion. The CO_2 may not run as high as it should, due to air leaks, but the best results shown by the analyses will indicate the proper thickness of fire.

If, in a horizontal tubular boiler, the highest CO_2 is less than 10 per cent. and with not more than 0.1 or 0.2 per cent. of CO present, air leaks should be looked for. If it is desired to get the CO_2 up to about 12 per cent., the setting will probably have to be painted with one or two coats of thick paint to prevent air leakage. The latter has a pronounced effect on the efficiency with any type, but is particularly detrimental with the horizontal tubular boiler, as in it all leakage mingles with the heated gases before they pass through the tubes which comprise about 90 per cent. of the heating surface in this boiler.

To discern if the fireman handles the fires properly at all times, a large receptacle, say of 5 gal. capacity, can be used for collecting the gas sample, and a continuous one taken over a 10-hour period. A portion of this sample may be transferred to a smaller sample bottle and analyzed the following day, if it is not convenient to make the analysis at closing-down time.

Draft Gage

A simple draft gage for use as described before, can be made of two glass water gages connected at the lower ends by rubber tubing, as in Fig. 5. The outfit is fastened to a small board and a paper scale is pasted or tacked to the board between the tubes.

Brown Double Flue Return Tubular Boiler

Patents have been granted James T. Brown, 71 Griswold St., Detroit, Mich., who has invented a new design of steam boiler. It is essentially a return-tubular boiler of ordinary make, to which two double flues are attached by water legs. These flues run diagonally across what would be the combustion chamber with an ordinary setting. The smokebox of the boiler is separated by a brick partition wall, as is also the furnace. These flues are built into the bridgewall at one end and into a separating wall at the rear end of the combustion chamber. As one flue is higher than the other by a little more than its diameter, the furnace grates are placed at a corresponding level and in line with the inside diameter of each flue.

The smoke chamber of the boiler is provided with a damper on each side of the partition wall. In operation one side of the furnace is fired and the products of combustion pass through the tube connecting to that side of the furnace into a rear chamber communicating to one-half of the tubes of the boiler. The gases then pass toward the front of the boiler through the small tubes and down through the open damper to the opposite furnace for the purpose of igniting the unconsumed gases by the flame in this furnace. The gases of combustion from the second furnace then pass through the second flue into the opposite partition in the back of the setting to the front of the boiler through the tubes on the other side of the boiler, escaping to the atmosphere.

When the second furnace is fired, the opposite damper in the smoke chamber of the boiler is opened and the same operation is repeated. In this way the unconsumed products of combustion after each firing are passed through a second furnace where they are ignited. This necessitates opening and closing a damper at each firing and also demands that alternate firing shall be used.

The Union Electric Light & Power Co., St. Louis, Mo., will lay 113 miles of electric cable to carry current to be derived from the Keokuk hydro-electric plant. The total cost will be about $1,000,000.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

Hunter explains mine haulage systems, what produces deterioration of the ropes and the method of inspecting them.

The stresses of ropes, due to load and the bending around sheave wheels, are important matters to consider in rope haulage systems.

While going to my room one evening my attention was directed to haulage cables by the slapping of the elevator ropes. This was a subject upon which Hunter had not touched, and meeting him later in the evening I produced a good cigar and informed him that I wanted some information regarding mine haulage, wear on ropes and other general data. We went into the grill room and while partaking of a light lunch, Hunter enlightened me regarding rope haulage systems.

Haulage Systems

"There are several systems of mine haulage," said Hunter, as he inspected a "bluepoint" oyster, "not including electric and air locomotives. There are four systems which may be grouped under rope haulage: the gravity plane, engine plane, tail rope and endless rope.

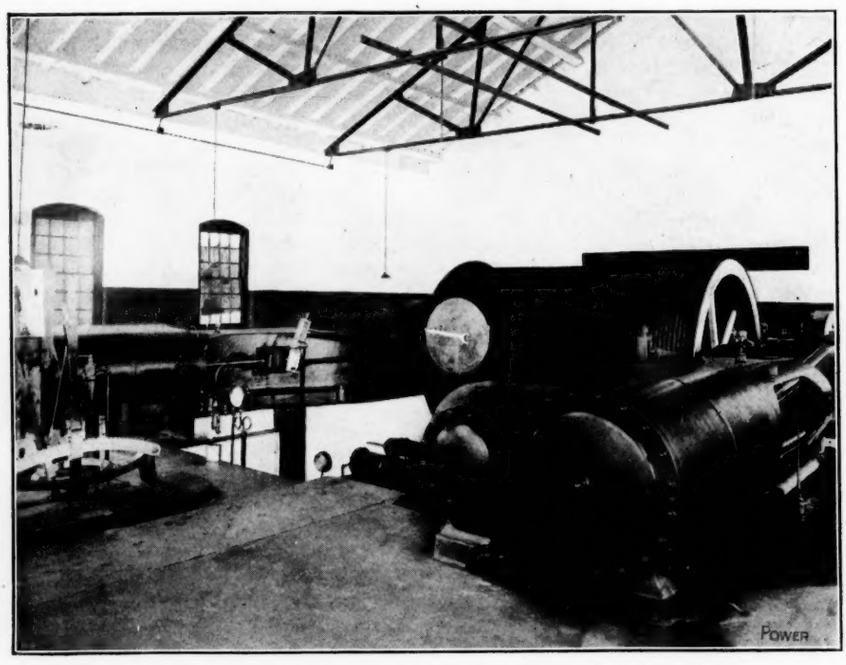


FIG. 1. HAULAGE ENGINE WITH STRAIGHT-FACED DRUM

"A gravity or inclined plane is one on which the gravity pull of the loaded cars will draw the empty cars to the top of the incline. No power is used to operate the system other than gravity. The tracks usually have a pitch of from 3 to 10 deg., according to the length of the incline. The rope is wound on a long drum; this is a better arrangement than when winding on a head wheel."

"Why is that?" I asked, nibbling a bit of salad.

"Because the head wheel is grooved and the rope will wind on the high side and wind off at the lowest point, so that there is a continual sliding of the coils of rope from the outside to the inside of the wheel groove. With a flat drum this surging of the rope does not occur. If two sheave wheels were used, one behind the other, the rope would wind around each, making a half turn at a time about them; but the wheels should be grooved similarly to the drums of winding engines. The speed of the cars is controlled by a brake arrangement at the drum.

Engine Plane

"An engine plane is an incline up which the loaded coal cars are drawn by a haulage engine (Fig. 1) located either in the mine at the head of the slope or on the ground surface. On some of the small engines the drum is loose on the shaft so it is not necessary to reverse the engine when 'empties' are run down the slope. On large outside engines the drum is generally secured to the crankshaft and the engine is run reversed when handling 'empties' down the plane. The other two systems of rope haulage are not so much used on slope work."

"It must be hard on wire haulage ropes, especially in wet mines."

Rope Deterioration

"It is," replied Hunter, "for they are subjected to excessive wear and tear. The deterioration of wire rope is both external and internal. The first is due to the rope wearing against foreign objects, and the latter from the chafing of the wires against each other. Another cause is permanent distortion, caused by overloading the rope or from bending around sheaves of too small diameter. Corrosion of the wire from acid water is another cause for deterioration."

Fig. 2 shows an arrangement of guide sheave wheels.

"I suppose a larger rope is used than is really necessary to handle the load to make up for the wear." I made this remark at a venture.

"That is the practice at some mines, the outer surface of the rope being made of as large wires as is possible for the diameter used.

"Some managers make a mistake by increasing the speed of the rope in order to handle a greater tonnage of coal, but high rope speed increases the wear and tear. A better way is to increase the load on the rope, within limits, of course, thus producing a greater output with a very slight increase in the wear on the rope."

"The strain on a cable must be tremendous if the load is not handled intelligently," was my next remark.

"Well, most engineers are careful in starting, but, of course, if care were not exercised in starting with a load the life of the rope would be shortened. Every hoisting rope about a mine should be inspected every morning before the men are allowed to get on the cage."

Examining the Rope

"How can a rope be examined, covered as it is with dirt and grease?" I asked.

"The best way is for the engineer to run the engine slowly and have a man at the rope to do the inspecting for any signs of weakness. This man passes a piece of hemp rope in a single turn around the hoisting rope, holding each end in his hands. If there are loose wire ends sticking out of the cable (Fig. 3), they will catch on the rope in passing. A bunch of oily waste is sometimes held in the hand and the cable allowed to run through it. If there are any broken ends projecting from the cable they will catch in the waste.

"Haulage cables are not so likely to cause serious accident by failure as are

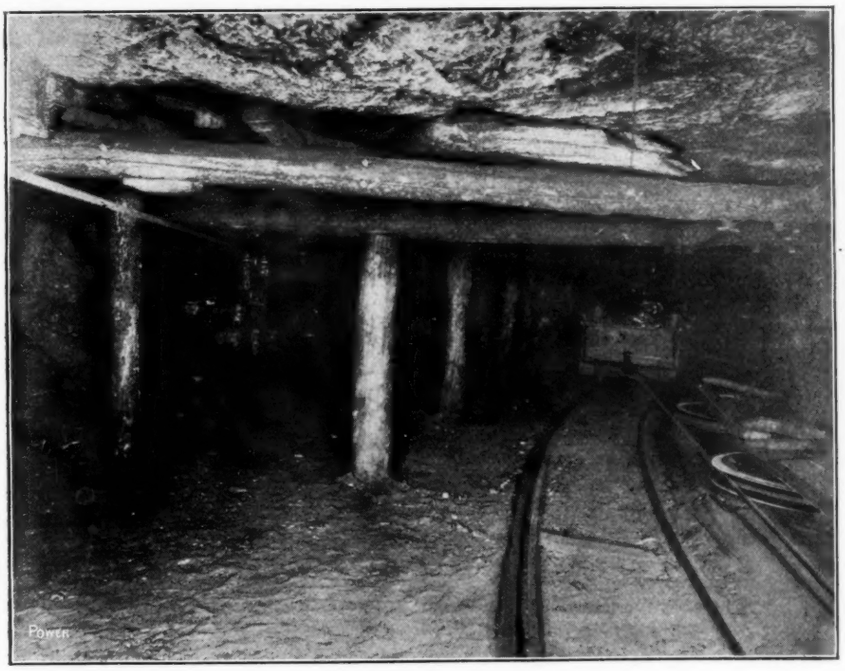


FIG. 2. ARRANGEMENT OF GUIDE SHEAVE WHEELS ON A CURVE

hoisting cables, and are therefore not discarded as quickly. Ropes with broken wire should be discarded and when the stretch has gone the rope should be replaced by a new one. Some superintendents do not wait until the rope shows signs of failure, but change it when a certain tonnage has been hoisted."

"Is there any particular place where a rope begins to give out?" was the next question.

"Surest thing in the world!" answered Hunter, as he dissected a small block of ice cream. "The first few feet of rope next to the cage, and where the rope enters the socket, are subjected to more severe shocks and sharper bending than other portions of the rope. The rope between the head sheave and drum when the cage is at the bottom of the shaft is also subjected to severe strains. Some ropes will give out much quicker than others."

ATTACHING THE ROPE

"How is the rope attached to a drum? It must be firmly secured as so much depends upon it."

"A common method is to pass the rope through a hole in the shell of the drum and twice around the shaft, the loose end being clamped to the protruding rope between the shell and the shaft. The precaution to observe is that of making the radius of the hole as large as possible so as to avoid a sharp bend at that point."

"Isn't there something that can be used to protect the ropes? I know that some kind of dope is used on gears to lessen the wear."

"A common preventive against the action of acid mine water, and to eliminate wear to some extent, is the frequent application of tar and black oil. A compound for hoisting ropes is made from freshly slacked lime which is mixed with coal tar. It is applied by saturating a piece of waste and the cable run through it. For haulage ropes raw linseed oil, thickened with lampblack and boiled with an equal amount of pine tar, is used. Black oil is also used where friction grips are not employed."

One matter which was not clear to me was how the ropes were attached to the cable hook, cage and drums for a hoisting engine. When the question was asked, Hunter replied that a rope socket was used to fasten the rope to the cage.

"It has a tapered hole through the body," said he. "The rope is put through the small end of the hole, the end projecting a short distance. Then the end of each strand is untwisted, some of the wire cut out and the remaining wires are bent back on themselves. The rope is then drawn back into the socket and a round wedge is driven into the center of the rope to spread the wires against the socket.

"Rope thimbles are sometimes used instead of a socket. The rope is bent around the thimble and the end secured by clamps. Where hooks are used on haulage ropes they are linked to the thimble." Fig. 4 shows one method of attaching a chain and hook to a haulage rope.

ROPE SIZES AND STRESSES

"How do engineers figure the size of ropes to withstand the stresses?" I next asked.

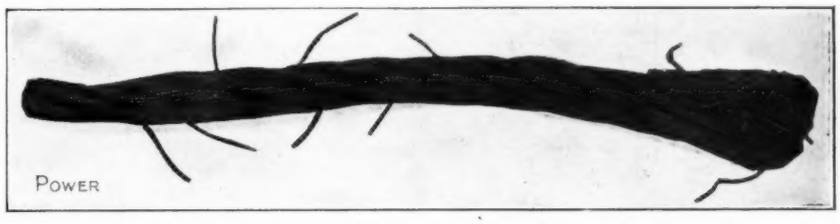


FIG. 3. CONDITION OF HOISTING ROPE AFTER SIX MONTHS' USE

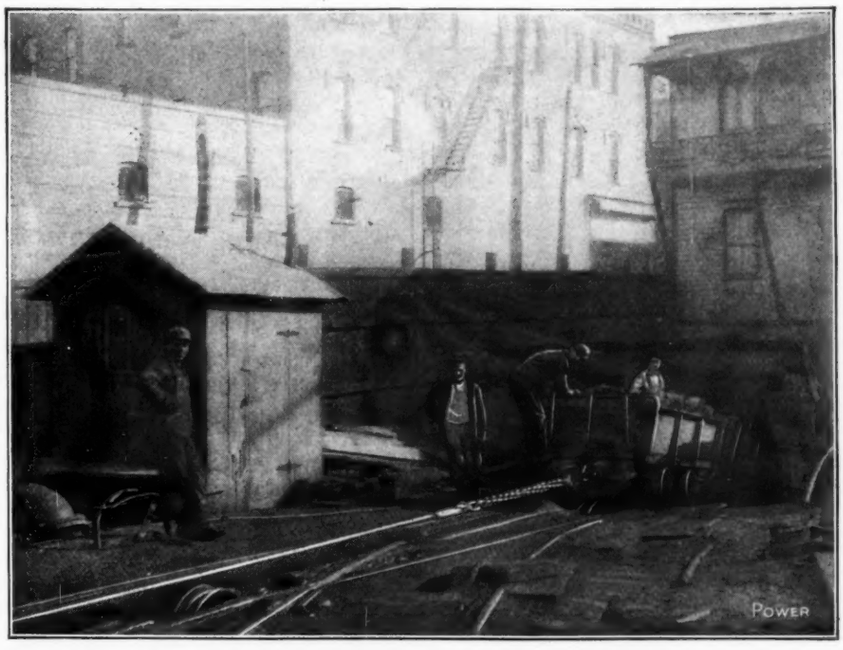


FIG. 4. SURFACE SLOPE OF THE SUSQUEHANNA COAL CO., NANTICOKE, PENN.

Hunter leaned back in his chair and said: "Say, you are the most inquisitive cuss I've ever met, but you are learning a whole lot. The working load of a hoisting rope is one-fifth of the breaking strength. In any event, the working load should never exceed the elastic limit.

"Now, there are two stresses on hoisting ropes, one from the load being handled and the other from the rope bending about the engine drum or around a sheave wheel. The latter stress is often given no attention when calculating the working load of a rope. This is one reason why some ropes fail unexpectedly; the bending stresses sometimes are greater than those exerted by the load.

"I have a table somewhere," continued Hunter, fishing through the contents of a long, bulging pocketbook. "Ah! here it is," giving me a blueprint bearing the heading, "Wire Ropes for Inclined Planes."* This table gave the tension on ropes from 1- to 90-deg. planes for a 2000-lb. load.

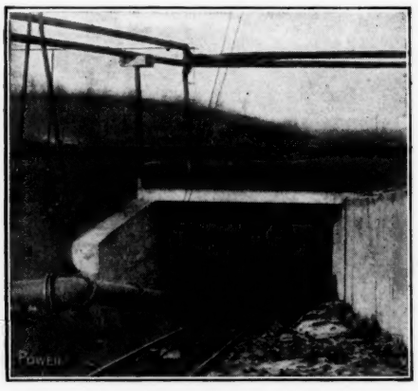


FIG. 5. HAULAGE ROPES DRAGGING ON GROUND BETWEEN SPOOLS

Wire Rope for Inclined Planes		Grade of Slope in Feet and Degrees	
Degrees of Incline	Tension on Rope in Lb. per 2000 Lb. load	Grade in Ft. in 100 Ft. of Incline	Incline in Deg.
90	2000	1	¾
80	1970	2	1½
70	1880	2½	1½
60	1732	3	1¾
50	1552	3½	2
45	1414	4	2¼
42½	1350	5	3
40	1286	6	3½
37½	1216	7	4
35	1148	8	4½
32½	1074	10	5¾
30	1000	12½	7
27½	922	14	8
25	846	16	8
22½	764	18	10 1–10
20	684	20	11½
17½	600	23	13
15	518	25	14
12½	432	26¾	15
10	348	30½	17
8	278	36	20
7	242	46¼	25
6	208	57¾	30
5	174	75	35
4	138	84	40
3	104	100	45
2	70	....	..
1	34	....	..

*Courtesy of the Hazard Mfg. Co.

"The total strain on a rope for shaft work is equal to the load lifted, the weight of the rope, the amount of frictional resistance to be overcome by the load and rope, and the amount of resistance due to acceleration of speed in hoisting.

"A thing which most hoisting engineers don't know is that this last factor enters into the strain upon the rope when conical drums are used. On inclines the resistance due to acceleration of speed enters into the strain upon the rope and varies with the angle of the slope."

"Well, tell me how to work this table?" said I, indicating the table shown herewith.

"In those tables no allowance has been made for frictional resistance or for the strain due to acceleration of speed in hoisting. To determine the strain upon a rope for a given slope with a given load, just multiply the strain per ton given in the table for the particular angle of slope by the number of tons in the load and make the necessary allowance for additional strain, indicated in the table, due to a sharp incline in the slope. A maximum of 150 lb. per ton is to be added for the rolling friction of the cars. Taking a factor of safety of from five to seven or a working load of from one-fifth to one-seventh of its maximum strength, the rope is in no danger of being overloaded."

Hunter arose, lit a cigar and as we passed out of the grill room concluded his explanation of ropes by saying: "The main thing about making a rope last is to run it over large-sized drums, sheave wheels and guide pulleys, which should be increased with the working load when it is greater than one-fifth of the ultimate strength of the rope."

As we passed the cleark's desk, he handed Hunter a note from a mine superintendent consenting to our viewing the mine-pumping machinery the next day. Not knowing what experiences might be encountered, I spent the rest of the evening getting together clothing suitable for the visit.

Absorbing Vibrations of Steam Mains

BY A. L. TEMPLE

Every operating engineer and superintendent of a steam power plant has experienced much trouble with vibrating steam mains and leaky joints. The writer was connected with a plant in which a 12-in. steam main had a tendency to vibrate and at times would set up a considerable end-to-end motion at a point where the pipe made a right-angle turn into the engine room from the boiler room. On visiting a neighboring plant a device was seen which suggested the one described.

The springs were made of ½-in. material, 2½ in. in diameter and 5 in. long. It was difficult to estimate the force causing the vibration and the writer knows no definite method of calculating it. However, the range of the springs to absorb the shock to which they must be subjected was calculated as follows:*

$$P = \frac{187{,}500\, F\, d^4}{R^3}$$

Where

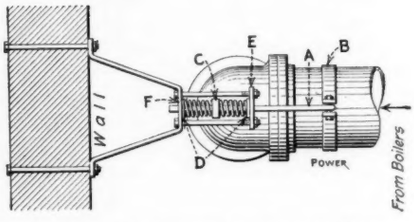
P = Load applied to the springs;
F = Compression of one coil;
d = Diameter of the wire;
R = Mean radius of coil, which is equal to ½ $(D - d)$.

Therefore:

$$P = \frac{187{,}500 \times 0.5 \times 0.5^4}{1^3} = 5850\ lb.$$

Therefore it is seen that a pressure of 5850 lb. will be required before the coils are tightly closed. From this calculation these springs were considered strong enough to use for a trial, and the device designed with the support f made of ⅜x2½-in. iron and the end piece e of the same material. The bolts on each side of the springs were threaded about 4 in. from the inner edge of the end piece e, so that sufficient tension could be put on the springs when the device was placed upon the pipe.

The sleeve washers d were turned to fit the holes in the pieces f and e and



ABSORBER ATTACHED TO STEAM MAIN

were grooved on the spring side so that each spring would get its pressure always in a true horizontal position. The collar piece c was threaded and screwed on the plunger rod a and secured by locknuts on each side. It was also grooved on each side to center the spring in the same way as at pieces e and f. The band b was made of ⅜x2-in. iron. The plunger rod was ¾ in.

After several adjustments of the springs, sufficient tension was found to absorb the vibration before the coils were compressed tight. However, at times there was a very slight vibration, lasting only a short time, showing that the adjustment was probably correct; the force of the vibrating main was something less than 5850 lb. in this case.

If there are other methods or data on the vibration of steam mains, they should be made known.

*Formula taken from Kent's Mechanical Engineers' Pocket Book.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Inspecting and Testing Electrical Apparatus—V

By A. L. Cook

Power Station Load Tests

After new apparatus has been put in service, it is often desirable to make a load run to determine the performance of the machine under specified conditions. Where it is not possible to use the regular station load for the purpose, some form of rheostat must be provided.

A water rheostat is generally used for loading a generator, its design depending upon the amount of load to be carried and upon the voltage. An ordinary wooden barrel may be used in making a small water rheostat, with one terminal placed at the bottom and the other arranged so that it can be raised and lowered to adjust the load. The terminal at the bottom should be covered by a piece of board so that it cannot come in contact with the upper terminal if lowered too far. The terminals may be of any convenient material, but generally an iron plate or casting is most easily obtained. The form and size of the bottom terminal is not very important, but the movable terminal should preferably consist of a triangular-shaped iron plate so as to vary within wide limits the amount of surface in contact with the water. A square foot of surface would ordinarily be sufficient for this terminal.

The water usually requires treating in some manner to reduce its resistance. Common salt can be used, but this is objectionable when the rheostat is indoors because of the chlorine fumes formed. Washing soda is very satisfactory for this purpose as it does not give off offensive fumes. Sulphuric or muriatic acid may also be used; in fact, almost any substance of an inorganic nature which is soluble in water, will serve the purpose. When adding any substance to the water to reduce its resistance, it should be remembered that as the temperature of the water rises, the resistance decreases greatly; hence the material should be added carefully. The objections to this type of water rheostat are mainly the difficulty of regulation for a steady load and its limited capacity. If water is run into the barrel steadily, a somewhat greater capacity is obtained, but the water escaping from the barrel carries with it some of the salts in solution, so that it is difficult to keep the strength of the solution and consequently the resistance constant.

When building a water rheostat to carry a definite load, it is desirable to have some data concerning the size required. The writer has found that 20 kw. carried on one barrel will cause the water to boil violently. If a barrel is used to carry as great a load as this, difficulty will be experienced in keeping the load sufficiently steady. If the evaporation caused by the boiling is replaced, by allowing a small amount of water to flow into the barrel continuously, about 15 kw. can be handled successfully. Starting with cold water the rheostat will carry heavier loads for a short period. For example, if the temperature of the water is 60 deg. F. at the start, it will carry 55 kw. for 15 min. before, the temperature exceeds 200 deg.

The water-cooled rheostat is much superior to the type just described. This consists of resistance wire, or iron grids immersed in water which is constantly circulated to keep the resistance cool. The load capacity of this type is limited only by the amount of cooling water which can be brought into effective contact with the resistance. No salt or other substance should be used, as the water is employed only for cooling and not as a conductor. The load capacity of a resistance contained in an ordinary barrel and furnished with a plentiful supply of water is surprisingly large. With ordinary cast-iron resistance grids or iron wire immersed in an ordinary barrel of water, 150 kw. can be carried continuously without difficulty. A ½-in. pipe can be inserted into the bottom of the barrel, with a suitable valve for controlling the supply of water. It is desirable to insert in this pipe, an ordinary insulating joint such as is used for combination electric and gas fixtures, to prevent grounding the circuit; the barrel should also be set on insulators. The water can be allowed to run out over the top of the barrel.

The carrying capacity of iron wire when immersed in water is much greater than in air. Table 1 gives the carrying capacity for ordinary sizes of iron wire. This data is calculated from a formula published in the *Electrical World*, May 6, 1909, and also gives approximate lengths of wire required for 125 volts; for other voltages the length can be calculated by direct proportion. The lengths of wire given are only approximate, as iron wire varies considerably in resistance.

TABLE I

Size, Birmingham wire gage	Carrying capacity amperes	Length feet per 125 volts
6	557	91
8	408	82
10	298	74
12	220	67
14	146	58
16	100	52
18	66	44

If the correct load is not obtained at first, it is an easy matter to change the length of wire and determine, by trial, the amount required; generally a single test will suffice. If the normal voltage is applied and the current is determined, the correct length of wire can be calculated from the equation

$$l = L \times \frac{C}{c}$$

where

L = Length of wire tested;
C = Current flowing during test;
c = Correct current;
l = Correct length.

For example, if it is desired to determine the length of wire required for 250 amp. at 125 volts, the required length of No. 10 wire can be calculated from the table and would be

$$\frac{298}{250} \times 74 = 88 \text{ ft.}$$

Assume that it is found by test that only 230 amp. flow with 125 volts applied. Substituting in the equation

$$l = 88 \times \frac{230}{250} = 81 \text{ ft.}$$

This equation assumes that the temperature of the wire remains constant. The tendency would be, however, for the resistance to increase and the current would be slightly less than the amount given by the equation. This will serve, however, to give the approximate length of wire required and save time in making trials. The iron wire can be made up in long spirals and mounted loosely on wooden rods, or can be wound spirally upon a wooden frame built to fit the barrel. It should be kept entirely immersed in the water when carrying current as it would soon melt if exposed to the air. Connection can be made to the coils by means of copper wires.

It is often necessary to make runs at several different loads. This can be arranged conveniently by providing several separate circuits of resistance wire, with switches for throwing on the required coils. The water-cooled rheostat is not readily adjustable but this is no drawback, since generally a constant load is required for testing. If it is necessary

to adjust the load slightly, an ordinary water rheostat with a movable terminal as previously described, can be connected in parallel, most of the load being carried by the water-cooled rheostat.

The water-cooled rheostat is most suitable for voltages up to 2200 volts. The other type, using electrodes immersed in a conducting solution, can be used for much higher voltages, but its use under these conditions requires special precautions. The same kilowatt load can be carried by a given size of water rheostat irrespective of the voltage of the circuit, the size of plate and the resistance of the solution being varied to suit the conditions. Sometimes when rheostats are used on high voltages, for example, 11,000 volts, the water available already contains sufficient impurities to give a suitable resistance. Care should be taken, however, that the voltage drop between terminals of a rheostat is not too great, as burning of the wooden tank would result. The writer has found that six barrels in series on 12,000 volts operate very successfully, and the number could be reduced to four with good results. One electrode in each barrel should be at the bottom and the other near the top, and the distance between them should not be less than 12 in. Variation of the resistance can be made only by adjusting the amount of salt or other substance in solution, as very little change can be obtained by raising and lowering the electrode. The barrels should each be set upon separate insulators and should not touch each other. The wire leading to the bottom terminal must be well insulated to withstand the voltage. It is not practicable to supply water to the barrels for cooling during operation; consequently the capacity is limited to about 15 kw. per barrel, as previously stated.

Generally tests made at high voltage require the absorption of large amounts of power, and in such cases barrels would be unsatisfactory. It is sometimes possible to place the terminals in a pond or river, but this method is somewhat limited, as it is impossible to control the resistance of the electrolyte. While a considerable variation in the resistance between the terminals can be obtained by varying the distance between them and the amount of surface immersed, it is not always possible to obtain the required load. If the surface immersed is reduced too much, arcing occurs at the surface of the terminal and the load becomes unsteady. It should be borne in mind that the largest part of the total resistance is near the terminals; consequently a considerable change in the distance between terminals will not make much change in the resistance; that is, if two plates immersed in a pond are 5 ft. apart, the resistence would not be doubled if the distance was increased to 10 ft. The size of terminal depends upon the current; pieces of iron pipe make good terminals, and need not be very large; a 4-in. pipe, 5 ft. long, being sufficient for 250 or 300 amp. An insulator should separate the terminal and the hoisting apparatus so that no current can pass along the rope and endanger the operator. Means for measuring the current in each leg of the circuit should be provided as a guide to the adjustment of the terminals. When trying a rheostat for the first time, it is best to lower the generator voltage as much as possible before connecting the rheostat so as to remove any possibility of excessive load.

Where the station load is greater than that required for the machine under test, the latter may be operated in parallel with the others carrying the regular load. The load on the machine being tested may be held steady by blocking the governor at the required position, and allowing the other machines to take the fluctuations in load. If the machine is run in this manner, care should be taken that the load is not thrown off with the governor blocked, as excessive speed would result.

When load runs are made, temperature readings should be taken of the principal parts of the machine, such as field and armature windings, field and armature iron, etc. The temperature of the rotating parts must necessarily be taken immediately after the test. The temperature of the air near the machine should also be taken, the thermometer being placed so as to avoid any current of hot air from the machine, but so as to give a reading fairly representative of the conditions of the air surrounding the machine. The bulbs of the thermometers used on the machine should be in contact with the part tested and covered with cotton waste to prevent radiation.

Machines are generally rated for a certain temperature rise above a room temperature of 25 deg. C., which is the temperature specified in the Standardization Rules of the American Institute of Electrical Engineers. If the room temperature at the time of test is not standard, the rules provide that the observed temperature rise shall be changed one-half of 1 per cent. for every degree Centigrade which the room temperature varies from 25 deg.

Storage Batteries

Tests of storage batteries would ordinarily take the form of discharge tests to determine that the battery has the specified ampere-hour capacity. Sometimes charge and discharge runs are made to determine the ratio of ampere-hours output to ampere-hours input. To test the ampere-hour capacity, the battery is discharged at a constant rate until the voltage drops to the specified value. The product of amperes discharged and the time of discharge in hours gives the ampere-hour output. The rating of batteries is usually based on the current that they will deliver for 8 hr., but it is not always convenient to make such a long run when testing. A sufficiently accurate test can be made by discharging the battery at a higher rate for a shorter time. For the ordinary type of lead storage battery, the performance at different discharge rates is given in Table 2, using the 8-hr. rating as 100 per cent.

TABLE II

Time of discharge, hours	Rate of discharge, per cent.	Ampere-hour capacity, per cent.	Voltage at end of discharge, volts
8	100	100	1.8
5	140	87.5	1.75
3	200	75	1.7
1	400	50	1.6

The battery can be discharged by means of a water rheostat or other form of load. Since the potential will be about 2 volts per cell at the start and will drop to 1.6 or 1.7 at the end, suitable provision must be made to keep the current constant during the test. After the battery is fully charged and has been allowed to remain on open circuit for about an hour, the specific gravity of each cell is observed; the discharge may then be started. A single cell should be selected as a pilot cell and frequent readings of its specific gravity, voltage and current made. The temperature of the electrolyte in this cell should also be observed. The voltage of each cell must be noted as soon after the start of the test as possible, and again near the end to detect any low cells. The discharge should be continued until the average voltage per cell, obtained by dividing the total voltage by the number of cells, reaches the specified value; which will be approximately that given in the last column of Table 2. After the test is finished, the specific gravity of each cell should be read to detect any low cells. If the temperature of the battery differs from 70 deg. F., upon which the standard guarantees are based, a correction should be made by allowing one-half of 1 per cent. change in ampere-hour capacity per degree Fahrenheit, the capacity being decreased for temperatures below 70 deg. and increased for temperatures above 70 deg. A change in temperature also affects the final voltage slightly, but for ordinary temperatures the correction is so small that it may be neglected.

Bulletin 4958, just issued by the General Electric Co., is an attractively bound book of 132 pages, devoted to the use of the "higher voltages" and their advantages in the operation of direct-current electric railways. It contains numerous tables comparing the costs of 1200-volt systems with those of 600 volts; illustrates and describes station and car equipments, locomotives for railroads of higher direct-current voltages, and describes the various systems employing

direct current at 1200, 1500 and 2400 volts. The bulletin contains a large amount of interesting information for electric-railway operators.

Tungsten Lamps for the Overloaded Plant*

By A. Gordon

The operating engineer often finds that the plant, which was quite ample when first installed, has become dangerously overloaded.

Not only must the floor areas be abundantly illuminated, but show cases, signs, and all kinds of decorative effects are demanded, and the installing of new lamps goes on so incessantly, that the last few additions may prove to be the proverbial last straw to break the back of the generating camel.

The 16-cp. lamps cost about 25c. each in barrel lots, and the current consumption is 3½ watts per candle, or about 13 lamps per horsepower. With 25-watt tungsten lamps, about 20 per cent. greater candlepower is obtained, and a horsepower will light about 30 lamps. The tungsten lamp offers a splendid opportunity to the operating engineer to economize in the plant with the least possible investment. In the overloaded plant, this lamp has proved a blessing; to the engineer suddenly called upon to provide light or power for additional areas, it offers the simplest solution.

In some buildings the space given to the steam and electrical plant is so limited, that to install an additional boiler or generating unit would upset the whole surroundings, or disturb established departments so much, that the outlay would hardly be warranted by the benefits received. If the plant is large, and the additional current required is for lighting only, and arc or carbon incandescent lights are in use, supplying additional light at small expense, is quite easy.

Assume that the plant has a total capacity of 2000 sixteen-candlepower lamps of 3.1 watts per candle or 50 watts per lamp, and 200 arc lamps taking 5 amp. at 110 volts or 550 watts per lamp. Then the generating units would have to supply 210 kw.

For the 50-watt carbon lamps, substitute 25-watt tungsten lamps, and the power required will be reduced 50 kw. and 19.1 cp. will be obtained per lamp or practically 20 per cent. more light than the carbon lamps give on the same current consumption. Or, if the wiring were rearranged, a very substantial saving could be made in the cost of renewals, as the larger tungsten lamps have a much longer life than the smaller sizes.

For the arc lamps might be substituted 400-watt bowl-frosted lamps, with reflectors, properly selected for the service required, and suspended at the proper height to permit using open prismatic reflectors, of either the intensive or extensive type, depending upon local conditions.

As the tungsten lamp is a depreciating light, and the tendency is always for more light, it is best to use at least 400-watt lamps in most cases. By replacing the 200 arc lamps with the same number of 400-watt lamps, 30 kw. will be saved, and with the 50 kw. saved by replacing the carbon lamps, 80 kw. additional is available for light or power. For power about 100 hp. could be used in motors, or an area equal to more than one-third of that supplied by the old lamps could be lighted.

The writer was obliged to furnish additional light and power, from a unit already overloaded. In 1906, 12,150 sq.ft. additional floor space was added, in 1907, 14,000 sq.ft., and in 1910 a fur room, which requires 22 kw. to drive the refrigerating plant. In 1911 a new building was erected at the rear of the building which shut off the daylight to such an extent that many arc lamps, previously run after dark only, had to be used continuously. This spring, 220 arc lamps were replaced with 300- and 400-watt tungstens, and, although additional lamps were installed, the load was reduced about 250 amp., and now another extension of lights or power, equal to 27.5 kw., is possible.

In addition to its load-reducing possibilities the tungsten lamp has many other advantages. Every engineer who has been responsible for the trimming, repairs, and maintenance of 300 or 400 arc lamps, knows the amount of trouble and labor involved in keeping them up to high efficiency.

When the internal mechanism becomes worn, and the insulation becomes charred, the resistance becomes defective and the current consumption has increased from 4.5 to perhaps 6 amp. per lamp. Where many arc lamps are used, there are sure to be some dead ones from some cause or other, and it usually is a nuisance to trim them. Burn outs of tungsten lamps are very infrequent and it only requires a few moments to replace a bulb.

In old plants where the wiring was not figured as liberally as it would be today, many circuits have become overloaded, the insulation deteriorated, and the copper crystallized so much, that the drop in potential has gone from 1 per cent. as at first calculated to even 10 per cent. in some cases. In other cases the wiring was so overloaded at the point of distribution that it was positively dangerous, when due care was not exercised in the proper use of fuses.

With the change to tungsten lamps, the cost for fuses should be reduced at least 50 per cent. The cost of glassware, especially inner globes, which is quite an item with arc lamps, would probably be sufficient to pay for renewals, when the 300- or 400-watt sizes are used.

For a new building, the cost of installing a plant for tungsten lamps, need not exceed 60 per cent. of the investment necessary, when arc or carbon lamps are used. At present it is possible to install a duplicate generating plant, with boilers of ample capacity, at less than a single plant would have cost a few years ago for the same service. With the use of tungsten lamps, the boiler plant can be reduced very materially, or, if boilers of liberal proportions are installed, a cheaper grade of fuel can be used to do the work. Anthracite screenings or buckwheat can be mixed with bituminous coal, in such quantities as will permit the plant to be operated without violating the most stringent smoke laws.

Only one objection has been advanced to using tungsten lamps in stores, that was in connection with the matching of colors. The complaint was more fancied than real as it was found that the ordinary inclosed arc lamp, when compared with the Day Light Arc or the Moore tube, was just as defective in the matching of certain shades of blues and drabs as the tungsten. Even daylight itself, when reflected from a red brick wall was found to be much inferior to the Moore tube for matching very delicate tints.

*Read before the second annual meeting, Institute Operating Engineers, New York City, Sept. 6 and 7.

CORRESPONDENCE

Burnt Spots on Commutator

In the July 16 issue, Mr. Hill answers Mr. Kramer's inquiry regarding burnt spots on the commutator. He mentions loose contacts, etc., which will probably cause burnt spots, but he did not mention irregular speed of the prime mover.

We have a two-cylinder four-stroke-cycle tandem gas engine, direct-connected to a 220-volt six-pole generator. The trouble started by the commutator burning in three equidistant spots; it kept getting worse and finally the burnt spots met. We turned down the commutator and tested for electrical defects, but found none. The machine ran all right for about four months, when the trouble appeared again.

The trouble was finally traced to the engine. There was poor compression in one cylinder and lost motion in the wrist and crankpins, which caused the engine to run unevenly and to pound. After correcting this the trouble disappeared.

The opinion seems general that high mica causes sparking, but I have always found on a well kept commutator that sparking comes from other causes, and the high mica is the result of the sparking, which burns the commutator and leaves the mica high and black.

J. C. Halvey.

Cooperstown, N. Y.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Some Ignition Troubles

By James H. Beattie

Designs of internal-combustion engines have been much improved during the past few years, particularly in reference to the ignition system. A few years ago the hot tube was the prevailing method of igniting the charges in the engine cylinder. Electric ignition was later developed, but for a long time it was not equal in reliability to the hot tube. It, however, possessed features superior to the older method, and designers devoted much attention to its improvement. Even with the improvements made, the ignition apparatus for a long time remained the most unreliable part of the engine. the custom being to use batteries with a simple induction coil. The demand for automobile engines with absolutely reliable ignition has perhaps done more to hasten the development of the modern high-tension magneto than any other factor.

Of late, manufacturers of stationary engines have followed the lead of the automobile-engine manufacturers, and are putting out engines equipped with "built-in" magnetos, driven by gears, in many cases so designed that the engine may be started without batteries. The liability of trouble from the ignition apparatus has been much reduced. It will be interesting to see how such apparatus will succeed in the hands of the average operator. Of course, the high-tension magneto is harder for the average operator to understand than a set of dry cells and a spark coil, but the liability of trouble is so much less that the average operator can afford to call the expert when trouble does occur.

The owner of a small vertical engine, fitted with make-and-break ignition, supplied by a set of batteries, complained that it missed and backfired. The batteries were in good condition, but it was found that the points of the igniter did not remain in contact long enough to allow the current to build up sufficiently to give a spark hot enough to ignite all the charges, some of which passed into the exhaust unburned and resulted in muffler explosions. Adjusting the igniter trip rod so that the points remained in contact longer effectually cured the trouble.

In another instance a similar engine fitted with the same type of igniter missfired, due to the points being corroded and pitted so as to make poor contact; one point was deeply pitted while the other was considerably longer than it had been originally. This condition is common with make-and-break igniters where the direction of the current is the same all the time; particles of the platinum are carried from the positive electrode and deposited on the negative, causing it to build up. Reversing the wires of the igniter from time to time will prevent this.

It would seem that short-circuited spark plugs or run-down batteries would be apparent to almost anyone, but for such troubles the repair man is often called. Many operators think their batteries are all right, and go so far as to prove it by testing the size of the spark. They fail to remember that a battery having energy enough to give a good spark in testing may be so nearly exhausted that it will not ignite the charges successfully. The real condition of a battery can be ascertained only by an ammeter. The amount of current necessary to operate one engine may be insufficient for another, due to one having a more efficient igniter, and also due to the location of the igniter. If the igniter is located in a part of the cylinder where it is exposed to fresh gas it will operate more surely than if located in a pocket where exposed to burned gases.

A puzzling case of miss-firing was traced to one of the make-and-break igniter points being loose. The point was inserted in a hole drilled in the movable electrode and secured with a small setscrew. The setscrew had worked loose so that the point had slipped back and did not make good contract with the other point. This method of securing the points is very poor, both because the setscrew may work loose and because the heads are likely to become hot and cause preignition.

An interesting case showing how the location of the igniter affected the operation of the engine, was that of a small horizontal engine operating a deep-well pump. The ignition had always given trouble, as ten fresh dry cells were required, and this caused the igniter points to burn because of the strong current. The igniter was located in a pocket in the cylinder head, and a hole about 5/8 in. in diameter communicated from the igniter pocket to the cylinder proper; this hole was nearly 3 in. in length. The repair man could not rectify this, however, as the mistake had been made by the designer. The igniter being located in the pocket was exposed to burned gases practically all the time, there being no opportunity for the pocket to be scavenged, which accounts for a very strong spark being required.

An engineer complained that his engine had a knock which he could not locate. The bearings were in good condition and the trouble proved to be due to too early ignition. The igniter was located over the inlet valve and was exposed to fresh mixture; hence the engine did not require as early ignition as other engines with which the engineer was familiar. The rate of propagation of the flame through the compression space is determined largely by the location of the igniter; hence some engines require earlier ignition than others.

Heat Value of Liquid Fuels

By A. A. Potter

The heat of combustion of a fuel can be determined from its chemical composition, but more easily by means of a calorimeter, in which the products of combustion give up their heat to a known weight of water.

The fuel in a calorimeter may be burned at constant volume or at constant pressure. The various bomb calorimeters, such as the Mahler, the Parr and the Emerson belong to the constant-volume class. In this case a weighed quantity of the combustible is burned with oxygen in a stout receptacle, or bomb, placed in a vessel containing a known weight of water. Ignition is affected by a hot wire, or by an electric fuse, the combustion producing a temperature rise of the water surrounding the bomb. Multiplying the temperature rise by the known weight of water, and dividing the product by the quantity of combustible in the bomb, gives the heat value of a unit weight of the combustible.

A well known calorimeter of the constant-pressure type is the Junker's, a brief description of which will be given for those not already familiar with its operation. Fig. 1 shows this calorimeter arranged for testing gaseous fuels. The gas to be analyzed, after passing through the meter M and sensitive regulator R, is consumed at constant pressure in a bunsen burner, and gives up its heat to water flowing through the calorimeter C. This calorimeter is somewhat similar to a fire-tube boiler, the products of combustion passing up the combustion chamber

and down through copper tubes, which are surrounded by water flowing in the opposite direction. For determining the heat value of liquid fuels, a burner and balance, as shown in Fig. 2, are substituted for the gas meter, regulator and bunsen burner.

In using a calorimeter of the Junker's type the heat of combustion is determined by measuring the amount of fuel burned, the quantity of water passed through the apparatus and the temperature rise of the water. Multiplying the weight of water passed through by the temperature rise and dividing by the amount of fuel used, gives the heat of combustion.

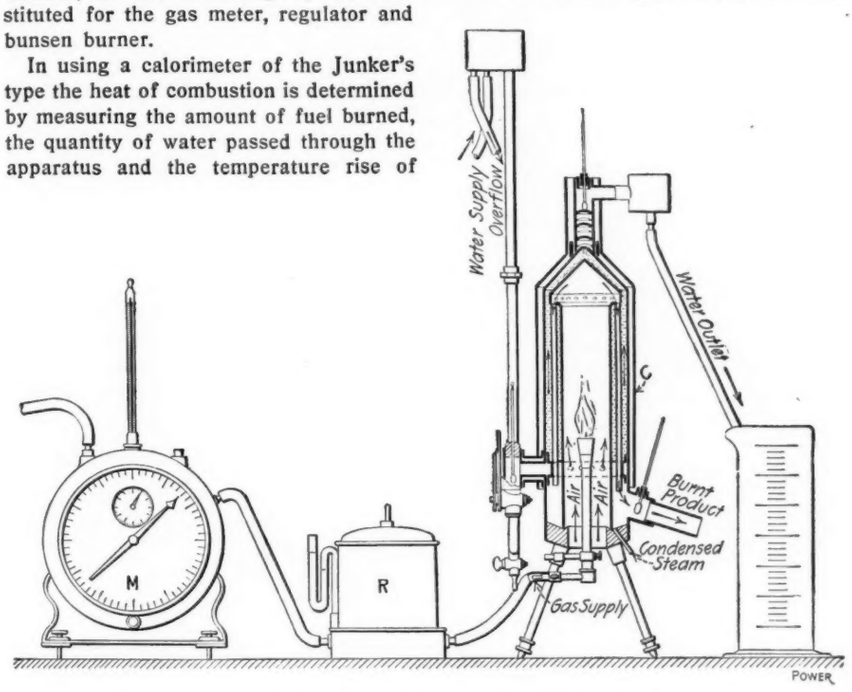


FIG. 1. JUNKER'S CALORIMETER AVERAGED FOR BURNING GAS

sene, solar oil and denatured alcohol by means of the Junker's calorimeter, the results of which are given in Table 1. These values represent averages of 28 runs in the case of gasoline, 29 for kerosene, 17 for solar oil and 21 for denatured alcohol.

The heat values are given in B.t.u. per pound, calories per kilogram and B.t.u. per gallon. From the values of B.t.u. per gallon it is evident that the cheaper petroleum fuels, such as solar oil, contain more heat units per gallon than do the lighter and more expensive fuels like gasoline.

The results of the tests also show that the heat of combustion does not differ much for the various petroleum distillates.

Table 2 was prepared as an aid in the conversion of degrees Baumé into specific gravity and in the calculation of pounds per gallon for liquid fuels.

TABLE 1. HEAT OF COMBUSTION OF LIQUID FUELS

Kind of Fuel	Specific Gravity (At 60° F.)	Degrees Baumé	Heat of Combustion					
			Calories per Kilogram		B.t.u. per pound		B.t.u. per gallon	
			High	Low	High	Low	High	Low
Gasoline	0.7380	60	10,790	10,220	19,411	18,415	119,400	113,300
Kerosene	0.7971	46	10,630	10,114	19,130	18,205	127,100	121,000
Solar oil	0.8250	40	10,429	9,965	18,770	17,940	129,100	123,330
Denatured Alcohol	0.7970	46	5,763	5,194	10,373	9,349	68,920	62,120

When a fuel contains hydrogen the foregoing method will give the high heat value, which includes the latent heat of the steam formed by the combustion of the hydrogen in the fuel. In the case of internal-combustion engines, the steam formed by the burning of the hydrogen in the fuel escapes through the exhaust uncondensed; hence the available heat is termed the low heat value which can be determined by collecting the steam condensed in the calorimeter, calculating the latent heat required to produce this weight of water at atmospheric pressure per unit weight of fuel, and subtracting the result from the high value.

TESTS WITH LIQUID FUELS

There being very little recent data published on the heat of combustion of the common liquid fuels, the writer made several series of tests on gasoline, kero-

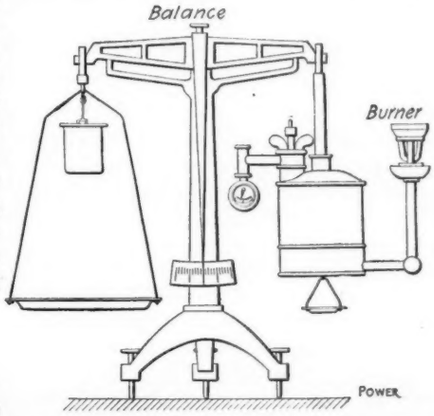


FIG. 2. JUNKER'S CALORIMETER ARRANGED FOR BURNING OIL

TABLE 2. RELATION BETWEEN SPECIFIC GRAVITY AND WEIGHT PER GALLON

Specific Gravity	Degrees Baume	Pounds per Gallon	Specific gravity	Degrees Baume	Pounds per gallon
1.000	10	8.336	0.775	51	6.462
0.993	11	8.277	0.771	52	6.428
0.986	12	8.220	0.767	53	6.394
0.979	13	8.161	0.763	54	6.358
0.972	14	8.104	0.759	55	6.324
0.966	15	8.051	0.755	56	6.290
0.959	16	7.997	0.751	57	6.258
0.953	17	7.944	0.747	58	6.212
0.947	18	7.891	0.743	59	6.195
0.940	19	7.837	0.739	60	6.163
0.934	20	7.785	0.736	61	6.133
0.928	21	7.736	0.732	62	6.101
0.922	22	7.687	0.728	63	6.070
0.916	23	7.638	0.724	64	6.038
0.911	24	7.590	0.721	65	6.006
0.905	25	7.541	0.717	66	5.975
0.899	26	7.493	0.713	67	5.946
0.893	27	7.444	0.710	68	5.916
0.887	28	7.395	0.706	69	5.886
0.881	29	7.347	0.703	70	5.856
0.876	30	7.298	0.699	71	5.827
0.870	31	7.254	0.696	72	5.797
0.865	32	7.210	0.692	73	5.771
0.860	33	7.166	0.689	74	5.743
0.854	34	7.122	0.686	75	5.715
0.849	35	7.079	0.682	76	5.688
0.844	36	7.038	0.679	77	5.659
0.840	37	6.998	0.676	78	5.632
0.835	38	6.696	0.672	79	5.603
0.830	39	6.918	0.669	80	5.576
0.825	40	6.878	0.666	81	5.548
0.820	41	6.839	0.662	82	5.517
0.816	42	6.804	0.658	83	5.487
0.811	43	6.760	0.655	84	5.457
0.806	44	6.721	0.651	85	5.427
0.802	45	6.683	0.648	86	5.402
0.797	46	6.644	0.645	87	5.374
0.793	47	6.608	0.642	88	5.353
0.788	48	6.571	0.639	89	5.316
0.784	49	6.534	0.636	90	5.304
0.779	50	6.498			

A resolution passed by the National Gas Engine Association reads: "It is the sense of this convention that the oil-inspection laws in Wisconsin and similar laws in other states are a burden to the consumer and unnecessary."

A further investigation of the oil-inspection laws of several of the states convinces us that they are inadequate for present conditions. In North Dakota and some other states, owners of traction engines cannot make use of low-grade fuels since the law under which oils are inspected makes no provision for admitting oils of this character. When there was no market for gasoline the tendency of the oil companies was to use as much of the volatile constituents as possible in the kerosene. Inspection was then necessary to protect the public. The old inspection laws are, therefore, practically obsolete. Furthermore, when these laws were passed nobody thought of using distillate for power purposes. What is needed now is either a modification of the oil laws which will enable the free sale of distillate or their abolishment altogether.—*Gas Review.*

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Heating in Connection with Steam Turbines*

By August H. Kruesi

Using turbines in connection with heating is advocated primarily because any work first done by the steam, as generating electric current, is almost wholly a gain as compared with using live steam separately for heating. Steam, after expanding, and giving up all of the energy available in a prime mover of perfect efficiency, can still give up the great bulk of its original heat when condensed in a heating system.†

As compared with the exhaust from noncondensing engines, steam from a turbine at the same pressure would contain substantially the same heat and amount of moisture, if the efficiency is the same. If the turbine is less efficient, the steam extracted from it must be dryer and contain more heat. The measure of the relative performance is the amount of electrical energy obtained as a byproduct from the steam extracted for heating, assuming the steam delivered to the heating system is of the same quality in both cases. In other words, the comparative performance is gaged by the water rates of the two machines. As between slow-speed Corliss engines of highest grade and turbines designed primarily for condensing operation the advantage, in the past, has often been with the engine, under usual district steam-heating conditions. In hot-water heating systems, the heat transfers are usually made at lower temperatures and correspondingly lower pressure, so that more work may be abstracted by the turbine with very little reduction in the heat value of the steam. Experience with such systems indicates that the turbine is on a parity, at least as to steam consumption, and points to the desirability of laying out district steam systems to employ the same low pressures.

*Abstract of a paper read before the National District Heating Association at Detroit.

†At a steam pressure of 150 lb. gage and a feed temperature of 132 deg. F., expansion to atmospheric pressure in a perfect prime mover would deliver 0.05 kw.-hr. per lb. of steam and leave 84 per cent. of the original heat in the exhaust steam, which would contain 13½ per cent. moisture. In a prime mover of 50 per cent. efficiency 92 per cent. of the original heat would remain in the exhaust and 4½ per cent. moisture. The latent heat of the original steam is 78 per cent. of its total, and most of it remains unimpaired after expansion, and available in any heating system working at a low enough temperature to condense the steam.

Turbines for Heating Work

The author illustrated one of a series of Curtis turbo-generators of new design now in manufacture, at present comprising machines of 500, 750, 1000, 1500 and 2000 kw. capacity for 60-cycle generators at 3600 r.p.m. While primarily intended to give good results in condensing operation, these machines have been especially designed with reference to extracting steam for district and industrial heating purposes. They have governing mechanism, valves, nozzles, etc., proportioned for a sufficient flow of steam to carry the full rated capacity noncondensing against back pressures up to 1 lb. gage with 150 lb. initial pressure.

The performance actually obtained on a 750-kw. unit running entirely noncondensing against atmospheric pressure, is shown in the accompanying diagram. Comparing curves *A* and *B* shows that, in the full-load region, the noncondensing performance of the machine designed to run condensing is practically as good as that of a straight noncondensing machine. The water-rate curve at 10 lb. gage pressure also shows good results.

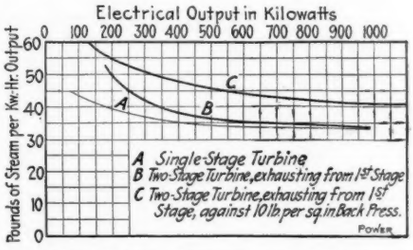
STEAM EXTRACTION FROM 750-KW. CURTIS TURBINE.

Gage pressure extracted steam	Steam extracted, lb. per hr.	Total steam to turbine, lb. per hr.	Combined water rate lb. per kw.-hr.
	Electrical output, 250 kw.		
—	0	5,600	22.4
0	9,200	10,000	40.0
5	4,000	8,200	32.8
5	10,500	11,600	46.3
10	4,000	8,600	34.4
10	12,000	13,300	53.0
	Electrical output, 500 kw.		
—	0	9,600	19.2
0	17,000	17,800	35.6
5	4,000	12,200	24.5
5	19,300	20,400	40.8
10	4,000	12,800	25.6
10	21,600	23,000	46.0
	Electrical output, 750 kw.		
—	0	13,700	18.25
0	25,000	25,700	34.2
5	4,000	16,200	21.6
5	28,200	29,200	38.9
10	4,000	16,900	22.5
10	31,600	32,900	43.9

The accompanying table shows how this turbine can be used to carry different loads, and at the same time deliver various amounts of steam to the heating system, together with the total steam consumption under the assumed conditions. The steam pressure was 150 lb. gage with no superheat and the vacuum 28 in. For back pressures of 5 and 10 lb. the table shows in each case the effect of extracting a small amount of steam and also the maximum amount obtainable under the conditions from a machine of regular design. The condenser is in operation for the balance of steam required to carry the electrical load. At the maximum, the steam extracted is substantially the same as the live steam to the machine, the stage valve in these cases being entirely closed. Curves *A* and *B* show that when extracting the maximum of steam, the condenser might be shut down without materially affecting the economy. These machines are not limited to the figures stated.

Variable Load and Automatic Valves

Operating turbines in connection with a heating system in some cases have been handicapped by a variable electrical load, and in at least one instance, operating a heating system from a turbine has been claimed actually to take more coal than


Electrical Output in Kilowatts
0 100 200 300 400 500 600 700 800 900 1000
Pounds of Steam per Kw.-hr. Output
60 50 40 30 20 10 0
A
B
C
A Single-Stage Turbine
B Two-Stage Turbine, exhausting from 1st Stage
C Two-Stage Turbine, exhausting from 1st Stage, against 10 lb per sq. in Back Press.
POWER

Water Rate Curves for 750-kw. Turbo-generator

operating independently, furnishing steam through a reducing valve to the heating system. An increase in electrical load will naturally increase the pressure in the turbine casing and, lacking any regulation to prevent it, will result in a corresponding increase of pressure in the heating system. The whole heating system must be raised in temperature to that of the increased steam pressure. Consequently, if the pressure is suddenly increased the steam-absorbing capacity of the heating system is very great while the pressure is rising. This will increase the draft of live steam to the turbine correspondingly, and may lower the pressure in the boiler room, which would lead to the conclusion that heating by extraction is wasteful of coal, because it is more difficult to maintain a steady steam pressure in the boiler room. The waste is probably more apparent than real in many cases. Consider an increase in pressure from 3 lb. gage to 5 lb., occurring at intervals, so that the higher pressure exists for half the time, the increased temperature and heat-radiating ability of the system, taking a room temperature of 70 deg., is only about 2 per

cent. Station operators will occasionally prefer to use live steam, irrespective of economy, from a disinclination to take the trouble to adjust a hand-operated controlling device to suit the variations in load, when it is so simple and easy to set a live-steam reducing valve to hold any desired pressure in the heating system.

To meet the requirements, however, of a constant heating-system pressure (which may be altered at will) under variable load conditions, an automatic valve-gear has been developed in connection with the new turbines referred to. The valve ports are arranged for successive opening or closing of the nozzles, all being either wide open or tightly closed and only one group subjected to throttling at a time. This valve may be hand actuated to supply variable amounts of heating steam.

An equivalent result can be reached with turbo-generators at present in use, by an automatic reducing valve between the turbine and the heating system. This will prevent an excessive flow of steam to the heating system with a sudden increase in electrical load, and thereby prevent waste of steam which must necessarily result from an attempt to maintain a given average pressure, with frequent variations in pressure, and consequently in temperature and flow. This arrangement cannot be quite as efficient as the automatic stage valve, because it involves some throttling of the heating steam, but this loss may be made small by occasionally adjusting the hand-operated stage valve.

Taking steam from turbines for heating systems is no more complicated than operating engines. A safeguard for the turbine must be provided, however, where there is more than one source of steam to the heating system, in the shape of a nonreturn valve. This prevents the turbine taking steam from the heating leader and so operating as a low-pressure machine, which might result in excessive speed if the circuit-breaker of its generator should trip or its load should fall to a low value for any other reason. Some turbines have been installed and used as high-pressure machines part of the time, and either wholly or partly as low-pressure machines at other times. This often can be done advantageously, simply by providing a connection between the turbine emergency governor and the nonreturn valve, so that the latter will trip in case of excessive speed. The latter would be automatically avoided under all ordinary conditions where the turbo-generator operates in parallel with the prime movers furnishing the steam. This makes a very flexible arrangement in existing plants containing steam engines and helps to maintain the best overall station performance under variations of electrical load and weather, which would otherwise fail to give a favorable relationship between the two loads.

Steam and Hot-water Systems

Some think that hot-water systems have an advantage in connection with power generation by reason of a lower back pressure, or even a partial vacuum on the prime movers. The writer has carefully studied this question in the heating of large factories and is satisfied that, if the prime movers are properly proportioned with respect to the two loads and of suitable type, there is no marked difference, if the steam-distribution system is designed for future growth and care to reduce the back pressure to economical limits. Using a vacuum return-line system has been found practicable in the largest industrial establishments. Some of these systems have more radiation surface than most district steam systems, and it would seem entirely practicable, and economical as well, to make use of this system, at least in part.

The balance of the paper was devoted to the measurement of exhaust steam under pulsating flow.

Ventilation of a Dispensary Building*

By A. M. Feldman

The building is a new dispensary attached to the Lebanon Hospital, New York City. Only one story and basement have been built, but provision has been made for five more stories. The first story, Fig. 1, contains a main corridor running the length of the building, with clinical rooms on both sides. The corridor serves as a waiting room for patients, and as considerable numbers congregate there at one time, efforts were concentrated on the ventilation of the corridor.

The scheme is to exhaust the air from the corridor. To admit fresh air all the radiators in the clinical rooms are direct-indirect radiators, Fig. 2, having fresh-air inlets through openings in the walls under the windows, with special galvanized-iron castings over the radiators that can be lifted to get at the radiators for cleaning. Only a few sections of each radiator are inclosed. To prevent cold air bypassing the radiator, the two sections next to the ends of the casing have solid legs.

The doors have louvers in the bottom

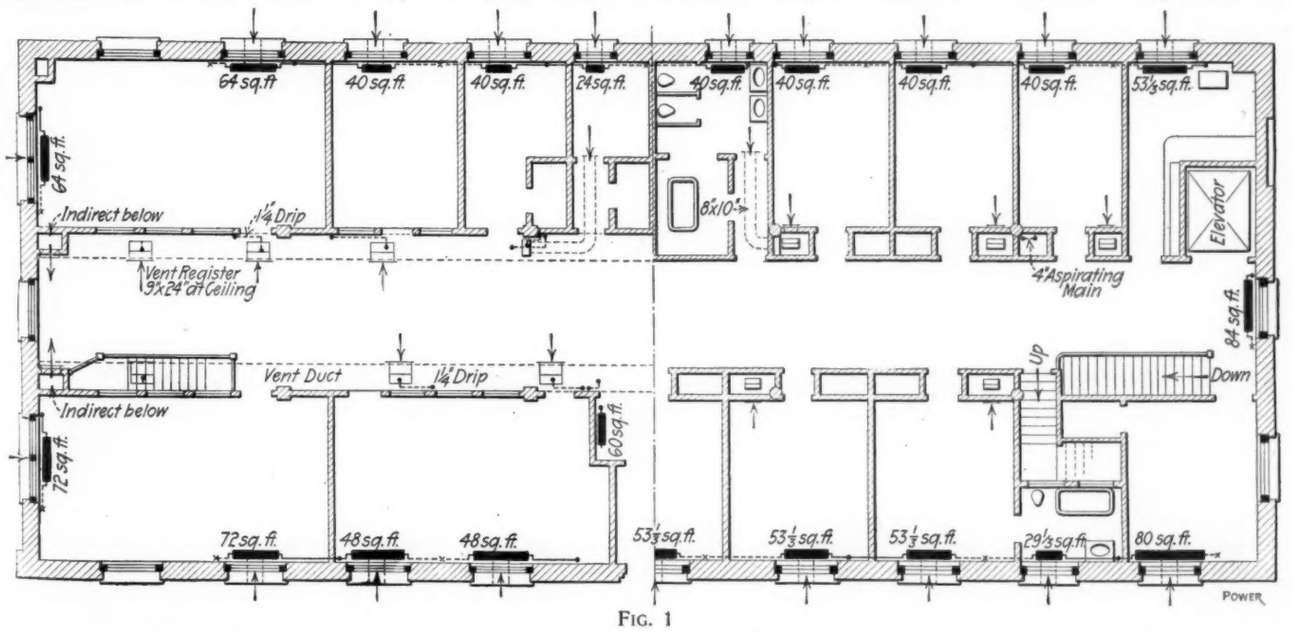


Fig. 1

Half Plan of Ground Floor — Half Plan of Future Upper Story

*Abstract of a paper read before the American Society of Heating and Ventilating Engineers at Detroit.

panel. Thus the exhausting effect of the system in the corridor induces air flow through the lower panels of the doors from the rooms which are supplied with tempered air by the direct-indirect radiators.

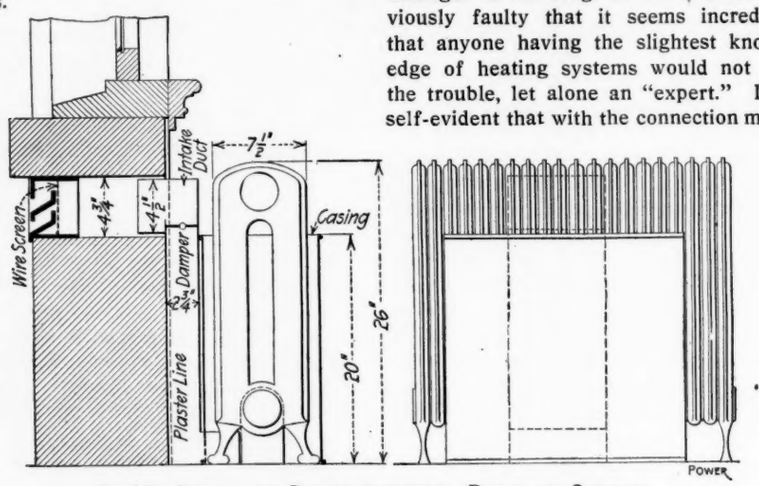


FIG. 2. DETAIL OF DIRECT-INDIRECT RADIATOR SETTING

To compensate for heat lost from the end windows of the corridor and to provide an additional supply of fresh air, indirect stacks are in the basement. These discharge air through large registers at both ends of the corridor. The ducts and registers are proportioned so that the air is heated not much above 70 deg. F.

Exhaust register boxes under the corridor ceiling pierce the concrete ceiling and discharge into a tightly constructed roof space where two 2½-in. steam mains

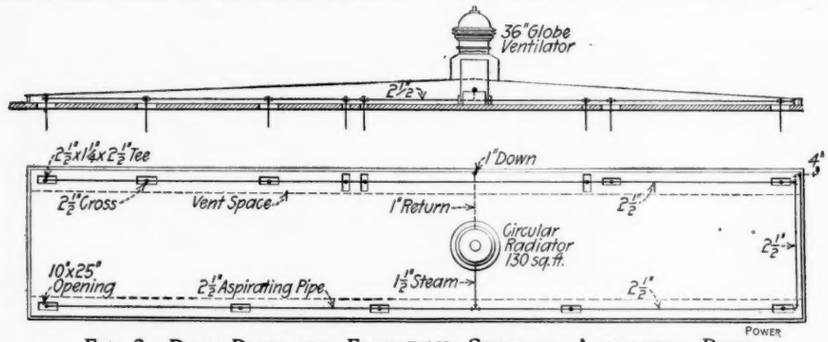


FIG. 3. ROOF PLAN AND ELEVATION, SHOWING ASPIRATING PIPES

and a 130-sq.ft. circular radiator furnish heat for aspirating purposes. Tees on the pipes allow extending aspirating risers through the future vertical ventilating flues required when the upper stories are built. A typical upper story floor is shown in Fig. 3.

No dampers were installed in the registers of the exhaust or on the indirects. But to prevent any unnecessary escape of heat after the dispensary closes in the afternoon, one main damper was installed in the ventilator on the roof, operated by a chain from the corridor. The damper is unbalanced so that it will always be open unless the chain is pulled down. The system has been in operation the past winter, and has proved a success.

CORRESPONDENCE

Expert Piping

The piping layout described by Mr. Essinger in the Aug. 20 issue is so obviously faulty that it seems incredible that anyone having the slightest knowledge of heating systems would not see the trouble, let alone an "expert." It is self-evident that with the connection made as shown the returns from the heating coils would fill the exhaust pipe above the back-pressure valve and then back up through the coils. This would cut off the escape of steam from the engine exhaust line and the back pressure would immediately rise until it was sufficient to overcome the back-pressure valve plus the head of water, when it would open, allowing the water collected above to fall into the feed-water heater and the pressure to drop until the valve closed. Then the cycle would be repeated. Obviously such a condition would lead to more or less flooding of the heating coils, to say nothing of the water-hammer due to the mixing of the water and steam when the back-pressure valve opens.

The obvious solution is to carry the return pipe from the coils to the feed-water heater. I would also advise Mr. Essinger to bleed the exhaust line just above the back-pressure valve.

W. L. DURAND.

Brooklyn, N. Y.

Mr. Essinger's system will not give satisfaction and is liable to cause serious trouble. Assume that the exhaust head is 25 ft. above the back-pressure valve and the return from the coil. If there is a check valve in the radiator return, what is to prevent the exhaust pipe above the back-pressure valve filling with water and producing

$$25 \times 0.437 = 10.925\ lb.$$

back pressure, which would mean at least 11 lb. at the engine. With an engine constant of 3 this would mean a loss of

$$11 \times 3 = 33\ hp.$$

There would, of course, be a slight increase in heat to the feed water, meaning perhaps 1 per cent. less fuel.

A more serious trouble would be the water-hammer. For a convincing argument it would only be necessary for Mr. Essinger to request the presence of the boss. Immediately after shutting down the engine, lift up the back-pressure valve with its load of water above. The solid thud of the water striking the heater plates will be instructive and may perhaps crack the heater. With the engine running and some pressure in the heater, if there is no drain above the back-pressure valve the pressure will force the water up the pipe with many a bang. I have seen an 8-in. cast-iron exhaust pipe cracked for 4 ft. of its length from this cause. Mr. Essinger's piping will undoubtedly be changed after a few trials. A better way would be to drain the coils through a trap to the heater, and a drain should also be placed in the exhaust pipe just above the back-pressure valve.

A. C. WALDRON.

Revere, Mass.

The only thing wrong with the connections shown by Mr. Essinger in the Aug. 20 issue is that steam as soon as turned on will condense in the radiators and run back through the return line into the exhaust pipe above the back-pressure valve until it fills the exhaust pipe and backs up in the radiators. The water on top of the back-pressure valve will prevent its opening until the back pressure in the exhaust pipe over-balances the water pressure. Then the engine may stop, or anyone that happens to be outside of the building will get a shower bath, and the plant will have to be shut down while the engineer makes repairs to the piping that may be broken by water-hammer.

The design is not only bad but dangerous. Before any heating is done it will be necessary to disconnect the return pipe from the exhaust pipe and connect it to a trap or vacuum pump and discharge the condensation either to the sewer or through an oil separator to the heater. If I was engineer in this plant I would rather run the chance of being discharged in showing the employer that this system is dangerous than try to run it and then be discharged as incompetent for causing serious damage to the equipment.

J. C. HAWKINS.

Hyattsville, Md.

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POWER

The Collegiate in the Power Plant

Although engineering colleges have for many years been graduating young men well equipped to enter the practice of engineering, who have proved their good judgment and ability by their works, the rank and file of power-plant operators are still more or less prejudiced against the college-trained man. This is due, in part, to at least four reasons, the treatment usually accorded to the beginner by the experienced man, misjudgment, envy, and a misunderstanding of what the college man is trying to accomplish.

Too much is often expected of the young man just out of college. During his four years of college work he has accomplished something more than simply accumulating facts. His reasoning power has been developed. He has learned to adjust himself to his environment or to change his environment if he finds it unsuitable. His ideals have been formulated, both professional and humanistic. He has been associated with his teachers who are, for the most part, also engineers of standing in their profession. He has gained from this association a rational viewpoint and he neither expects too much nor too little from his fellows. But in contrast to all this he is not a craftsman nor yet a professional man. He still lacks one prime requisite that the college cannot provide him and that is engineering judgment. This may only be acquired by meeting the tests and crises of everyday experience in his chosen work. He is likely to make the mistakes in judgment of any tyro and is worthy of the kindly criticism and patient consideration that should be given every beginner. Sadly enough, this is too seldom given either to the college man or to his fellow from the school of life. The experienced man reasons that he had a hard time getting what he now knows; therefore let the beginner dig, and especially let him blister if he is a college man. This is palpably unfair.

Human life is and always will be a great leveling agent. We do not stop to inquire, unless it be to satisfy our curiosity, whether the man who has made a success is college trained or not. To be successful he must possess some of the attributes of true greatness. Given two men of equal ability and enterprise, one college trained and the other trained only in the school of experience, the one may reach as high a professional standing as the other if they each give equal service.

One thing that apparently makes the practical man the natural enemy of any collegiate is the fact that the latter is willing to work for low wages to get a start. The man fresh from college is but a beginner and must expect beginner's wages. He is worth no more. While going through this period he is not the competitor of the experienced man. The fact that he is being paid an amount which is truly commensurate with the service he gives does not mean that wages will be lowered generally because of his action. He is merely a beginner and is receiving the consideration which is given to any beginner. The college man is not "undercutting"; he is simply paying for his experience while learning in the same manner as an apprentice. The practical man forgets that the college-trained man is not a finished product.

If any trade, craft, organization or profession is to continue to exist and to progress, it must give aid and consideration to the beginners. There is plenty for the young college man to do in the power-plant field. He cannot supplant the experienced operator unless the latter is willing to give up. Excellence demands full payment. There is no short cut to success. Whether we are college men or post graduates in the school of hard knocks, beginner or adept, let us not forget that we are all working to the same end and that we are all students in the great university of human experience.

Why a "Graduate"?

The United States Civil Service Commission announces an examination to secure eligibles from which to make certification to fill a vacancy in the position of engineer of tests at the Watertown Arsenal. An applicant must be a *graduate* in civil or mechanical engineering, of at least three years' experience, etc.

Again we protest against this graduate stipulation. The essential is, that the applicant shall know what he is required to know in order successfully to administer the position. It is nobody's business how he acquired this knowledge if he has it. There is many a civil and mechanical engineer who has got his knowledge by study outside of institutions authorized to issue degrees or certificates of graduation. They are just as adaptable to and just as useful in a position such as that under consideration, as a graduate engineer, and just as much entitled to its opportunities. It is the business of the Commission to ascertain if they have the required qualifications, and not how they got them.

Flue Gas Analysis

We have frequently called attention to the importance of flue-gas analysis, its advantages directly in increased economy of the plant, and indirectly to the engineer himself who gets the credit for bringing about improved conditions. We have predicted that gas-analyzing apparatus will become as essential a part of the boiler-room equipment as the indicator now is of the engine-room equipment.

When flue-gas analysis first began to attract notice, many regarded it as a means for the chemist to show off his knowledge, but nothing that would ever be of any practical worth, nor half so dependable as the experience of the trained fireman. Gradually the scoffers discovered that the analysis had real value and as the apparatus became somewhat simplified they found it was not so impractical as it at first appeared.

To one not familiar with it, it looks very complicated, and we have been glad to help disabuse those who regarded it so, with the series on "Flue Gas Analysis for Beginners," concluded in this issue.

Those who may have filed the article should correct two typographical errors that appeared in the first installment. On page 331 in the first column, next to last paragraph, pipette No. 2 should have been No. 3. In the next column, last paragraph, the reagent for the first pipette was for determining CO_2 and not CO.

Graphite in Boilers

There have been too many cases of the successful use of graphite for the prevention and removal of scale, and the avoidance of pitting in boilers, to leave its usefulness for this purpose longer open to debate. There may be differences of opinion as to why it does it, and how it does it, but in numerous cases the feeding of graphite into a boiler has not only prevented the formation of new scale, but has removed large quantities of scale already accumulated.

It is doubtless true also that in some cases graphite has been tried without success. It may be that graphite, like most other things, has its limitations, that it is very good in some cases and not in others. It may be due also to the kind of graphite used, and how it was applied.

The action is probably a mechanical one. The presence of the graphite in the scale destroys the adhesion of the particles which would otherwise weld themselves solidly together, so that the scale either does not form, or is easily broken up by the disturbances incidental to the ordinary operation of the boiler. But it is essential that the right kind of graphite should be used. One is apt to think that, while nothing but the most refined product is fit for a bearing, anything will do for so crude a process as mixing with boiler scale to make it brittle. The crudest product of the graphite companies, such as is sold to foundries for facing molds, etc., is therefore used, with the consequence that a lot of the worst kind of scale-producing material is deliberately pumped into the boiler, and not enough real graphite to counteract its effect, combined with that of the scale-forming material already present.

It is no proof of the adaptability of a graphite to the purpose in hand that it is high in carbon. Coal is carbon, so is sugar, but they would not do. The graphite must be not only pure, free from sand and other foreign substances, but it must have the lubricating and preservative properties upon which its action in the boiler evidently depends.

We shall be glad to have accounts of *bona fide* instances of the use or attempted use of graphite in boilers, and the results obtained, with enough of the conditions and attendant circumstances to indicate to others who desire to try the experiment the best way to proceed.

Four Pass Boilers

The advantage of using four instead of three vertical passes with horizontal water-tube boilers is being seriously discussed. With such a construction it is advisable to make the tubes twenty feet long in order not to restrict the passages for the gases. It can be easily seen that under certain conditions this type has several advantages over the three pass. In the first place, it has been demonstrated that the temperature of the escaping gases is from twenty-five to fifty degrees Fahrenheit lower, which, of course, means that less heat goes up the stack.

Probably the greatest objection to the four-pass boiler is its increased draft requirements, which must be taken care of by increasing the height of the stack or by some other means. This increase, however, would at the most not be greater than the draft necessary for a three-pass boiler with an economizer; in fact, it is doubtful if it would be as great, whereas the increased efficiency due to the lower stack temperature would more than offset it. Other objections are one more baffle to keep tight and a longer boiler setting and longer tubes to contend with. On the other hand, no breeching is required, as the gases can be brought down through the last pass into a flue underneath the floor and thus out to the stack, which arrangement gives a clear space at the side of the stack for the breeching connection. As for the extra baffle, it is very little more trouble to look after it when tending to the other two, and blowing off the longer tubes is a small item. To prevent an increased tendency for air infiltration because of the longer setting, a covering can be applied which in itself is an economical investment no matter how long the setting.

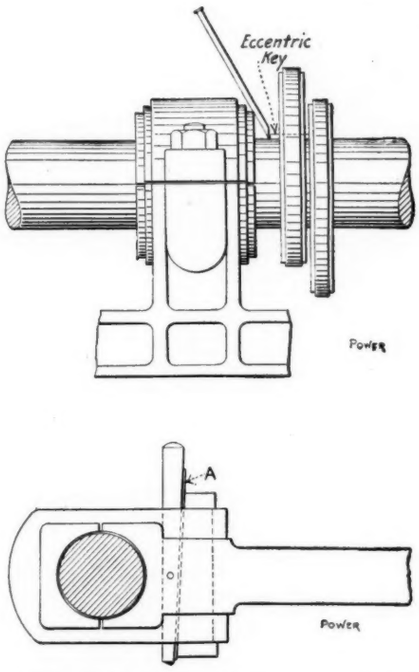
These objections, therefore, are not very important except, perhaps, that of greater draft, but when they are all put into the balance with the fuel saving resulting from the extraction of from twenty-five to fifty degrees more heat from the gases it will no doubt be found that they are greatly outweighed.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Key and Gib Kinks

While employed aboard a high-speed passenger vessel, I saw an engineer use a very ingenious way of overcoming a loose eccentric key. After driving the key back to its proper position, a portion of the shaft in front of the key was projected by means of a chisel bar and sledge, thus holding the key from working out and also making it fit the keyway closer. While it was necessary to stop the engine about five minutes, it saved much time, for, as shown by the illustration, to remove the key the bearing cap would have to be removed. After reaching port the shaft was hammered down and smoothed and a new key fitted.



SHOWING ECCENTRIC KEY AND POSITION OF LINER FOR ADJUSTMENT OF BRASSES

Another kink of probable interest to engineers who have gib and key connections about the plant, is the following manner of keying them up: Find the amount of clearance to give the bearing, then cut a slip of paper brass the thickness of the clearance and the same shape as the key. For example, it is desired to give the bearing 0.008 in. clearance. Cut the slip from 0.008-in. paper brass, place it on top of the gib between it and the key, as at *A*, Fig. 2, then drive the key up solid. Mark the key and drive it out enough to remove the slip and then drive it up to the mark and the bearing will have 0.008 clearance.

HENRY C. BRIGGS.

Jersey City, N. J.

Emergency Repair to Air Compressor

In a New England manufactory using considerable compressed air in operating its machinery, an accident occurred recently which, for the moment, indicated a protracted shutdown of some parts of the plant.

A split tube in the intercooler of a 12 and 20 by 8-in. cross-compound belt-driven air compressor flooded the high-pressure side of the machine and resulted in splitting the cylinder from end to end entirely through both the cylinder and jacket walls. The only other compressor in the plant, a 10x10 duplex belt-driven machine, set up adjacent to the cross-compound, was incapable of supplying the demand even when operated at its highest speed.

When a shutdown of some departments seemed inevitable, the trouble was reported to the manager. Evidently he had had a similar experience, for he instantly issued orders to take out the broken high-pressure cylinder on the cross-compound machine, disconnect the rods and connect up the outlet of the intercooler on this machine to the suction opening on the small duplex machine. From the position of the machines in the engine room, this connection could be made very readily.

The alterations were completed in a few hours. The unloading device on the suction of the cross-compound, low-pressure cylinder throttled down and adjusted to maintain 25 lb. air pressure in the intercooler. and the combination unit started. The results were entirely satisfactory. With some slight adjustment of the pressure regulator on the duplex compressor, it was found that when supplied with air at an initial pressure at 25 lb., the machine delivered all the air required for the plant's operation.

This makeshift arrangement kept the plant in operation until a new high-pressure cylinder was procured for the cross-compound compressor. For several days after the cylinder had been received the air supply was sufficiently satisfactory to warrant the continued use of the combination compressor until a good opportunity presented itself to install the new cylinder.

A comparison of the indicator diagrams taken from the small compressor under the ordinary operating conditions with those taken when supplied with the air at 25 lb. from the low-pressure cylinder of the cross-compound show that the volume of air delivered by this compressor increased very rapidly with the increased pressure on the suction.

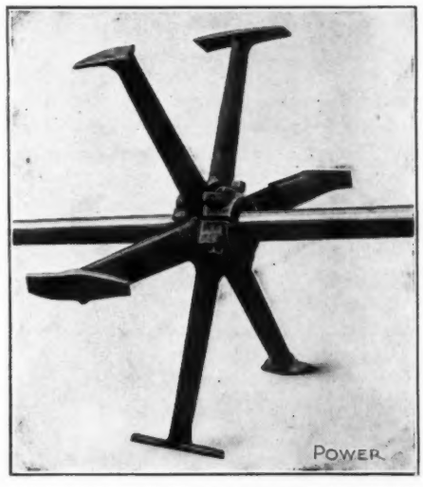
W. M. FLEMING.

Holyoke, Mass.

A Fractured Pulley

The illustration shows the result of a curious and interesting mishap to a pulley, due to a belt slipping off the driven pulley and remaining on the driver.

The fractured pulley was on a countershaft about 6 ft. long and $1\frac{15}{16}$ in. in diameter. There was nothing to restrain the free motion of the countershaft as the machine it operated was located on the floor above and driven by a binder pulley. The machine was not running and the operating belt hung loosely, so that the countershaft was free to revolve without hindrance. The countershaft, driven by a 4-in. double belt, was 20 ft. from the main or driving shaft.



SHOWING EFFECT OF CENTRIFUGAL FORCE ON PULLEY

The belt was long, soft and flexible, and of a special tannage, and when it fell on the shaft, clung reasonably well. The driver was 24 in. in diameter and made 250 r.p.m., and as the receiving pulley was likewise 24 in. in diameter, the normal speed of the countershaft was 245 r.p.m., allowing 2 per cent. for slip.

When the belt was down on the shaft, however, which was slightly less than 2

in. in diameter, the acceleration was 12 to 1, or might possibly have reached 3000 r.p.m., the slippage of course greatly reducing this result, as the belt was loose. The speed increased sufficiently, nevertheless, to fracture the pulley through the centrifugal force developed, a peripherial speed of probably 8000 to 10,000 ft. per min. having been reached before rupture.

The fragments scattered in many directions, one piece cutting into a 2-in. plank to a depth of 1½ in. as cleanly as if it had been cut with an axe. Another travelled 75 ft. across the ceiling, penetrated a window, cleared a roadway 22 ft. wide and struck a locker in an adjoining building. A third passed through a lunchbox hanging on a post 50 ft. away.

The entire incident might have been avoided by the use of an ordinary belt iron or hanger, and while it is our practice to take every precaution, this was one of the numerous locations where no provision had been made.

H. E. OSGOOD.

Wilmington, Del.

Emptying an Oil Barrel

To empty an oil barrel is more or less a troublesome job. We draw our daily supply from three storage tanks for use on gas engines and a supply of oil has also to be placed in the engine crank cases from time to time, to replace that used or drawn off when the machines are cleaned out.

The arrangement shown in Fig. 2 has more than paid for itself; it spills no oil on the floor and eliminates all the strong-arm work of lifting the barrel. It consists of a gooseneck *A* made of ¾-in. brass pipe; the short end acts as a spout and can be inserted into the filling hole in the tank or run into the crank case.

The long end will reach the bottom of the bulge in a barrel when inserted through the bunghole and takes out nearly every drop of oil. A 1x¾x1-in. tee *B* can slide up and down on this leg, making the device adjustable for use in drawing oil out of receptacles having a hole big enough to admit the pipe. A ¾-in. short nipple *C* at the lower end of the tee can be fitted into the barrel bunghole, the thread on the nipple making a joint usually tight enough for the purpose. If the bunghole is large, some waste will make this joint tight. The upper 1-in. outlet is fitted with a reducer *D* and babbitted to fit the brass tube. This serves as a gland, as a little oil makes it slip easily on the tube and at the same time acts as packing. The 1-in. side outlet is fitted with a reducer *E* into which a brass tube *F* about 3 in. long is screwed, the outer end being screwed into a brass bushing whose outside is threaded to fit a ½-in. hose coupling *G*.

A small electrically driven air compressor *H* was available which supplied compressed air for starting the engines. A globe valve and a tee were inserted in the line leading to the air receivers, Fig. 1. From the outlet of the tee a line was run over to the oil storage tanks where it connected with a ½-in. hose about 8 ft. long. A globe valve controls the admission of air to this line in which a small pop safety valve *J* with a light spring limits the pressure to about 7 lb.

When a barrel is to be emptied into one of the tanks it is rolled in on the floor and blocked. The gooseneck is inserted through the bunghole and the ¾-in. nipple screwed in to hold it; the brass pipe reaches to the bottom of the barrel and over the tanks *K*, *L* and *M*. The

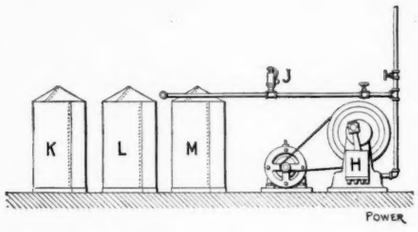


FIG. 1. ARRANGEMENT OF PIPING

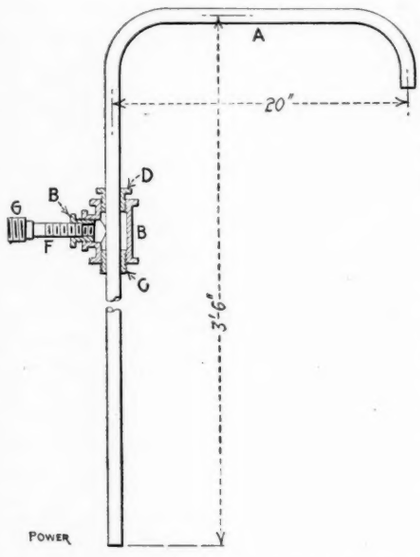


FIG. 2. DETAILS OF AIR-OIL LIFT NOZZLE

globe valve controlling this line is opened and the compressor is started pumping air into the barrel while the oil flows into the tank. The device requires no further attention until the barrel has been emptied, which is known by the air coming out of the spout.

The safety valve with the 7-lb. spring is an important accessory. Some oils are not as fluid as others, and the carrying capacity of the ¾-in. brass gooseneck is limited. With a heavy oil the air pressure may rise rapidly; the safety valve limits the rise to a pressure the barrel can safely withstand and one sufficient to overcome the hydrostatic head of the oil. The omission of the safety valve may give the installer of such a device a very "messy" lesson in elementary hydrostatics, the partial loss of the oil and the total loss of the barrel.

E. ELLSWORTH.

Cleveland, Ohio.

Specifications for Dutch Ovens

Will some fellow-engineer state in POWER a desirable method of building an ignition arch or dutch oven in connection with return-tubular boilers 60 in. by 18 ft., using oil as a fuel?

Possibly some reader with experience has the patterns for a suitable framework for supporting the tiling, and will give the desired information as to the size and shape for the best results.

F. B. DAGGETT.

St. Joseph, Mo.

Loose Valve Stops Pump

Recently I stopped our feed pump to test an injector I had set up. After trying out the injector to my own satisfaction, I told the fireman to start the pump. A few minutes later he reported that it would not start. This surprised me as it had run well all the morning. I tried it myself and it made a few strokes and stopped. Thinking the valves had been displaced in some way, I removed the steam-chest cover, but found them all right. I then opened the water end, thinking one of the follower plates might have become loose and jammed, but found the piston and valves in order.

I then tried to move the rods with a bar, and they moved easily. I put everything together again, removed the bonnet of the exhaust valve and, as I suspected, the disk had come loose and fallen off the stem square on its seat. The pressure on the top had closed the valve tightly. I screwed the disk-holder back on the stem, put the valve together, turned on the steam and the pump then ran without further trouble.

E. C. GARLICK.

Milwaukee, Wis.

Knocks in Air Compressors

We have a duplex two-stage air compressor in operation nine hours a day and seven days a week. Some Sundays the main part of the power plant is shut down and the engineer goes to church, leaving the compressor and pumps in care of the oiler.

One Monday morning before starting up, the oiler reported that the compressor began knocking about Sunday noon and got steadily worse toward the close of the day. After starting the main engine, the engineer went to the compressor and opened the throttle, thinking to turn it over slowly and locate the trouble. It made two or three turns, when the crank

disk broke through the pin-bore. An examination showed that the piston rod, working loose, had unscrewed about ⅛ in. out of the crosshead, taking up all the clearance on the head end and the air piston, striking the head, caused the fracture through the crank disk.

Everything was stripped on that side of the compressor, but aside from the broken crank and a bent connecting-rod no further damage was done. A 1¾x3½-in. steel band was forged and bored $\frac{1}{16}$ in. less in diameter than the 26x3½-in. disk and shrunk on. The compressor has been in operation two months since the accident and the crank is as rigid and runs as well as ever.

Another accident happened to this same compressor that may be of interest. A new engineer, not familiar with compressors, had charge of the machine. One morning in starting up he forgot to open the air-discharge valve on the high-pressure side. The machine turned over two or three times, but had to be shut down. Finding the outlet closed, he opened it and started once more. Everything seemed to go all right until the pressure got up to about 50 lb., when there came a clear metallic knock on the high-pressure side as the crank was on the low quarter or the low-pressure crank was at the crank end. The sound seemed to be in the pillow block or crosshead. The quarter boxes were taken up and the crosshead shoes adjusted, the crank brasses examined and even the wristpin taken out and refitted, but still the knock remained.

As everything else had been examined, the cylinders seemed the only remaining points of attack. The steam cylinder showed everything to be all right, and it was not until the air piston was taken out that we found the trouble. The piston jam nut had become loose so that the piston had about $\frac{1}{16}$ in. play on the rod. When the low-pressure piston reversed its direction from the crank end, the fresh charge of air into the high-pressure cylinder would cause the piston to jump back against the nut, causing the knock. On the other stroke the tapered end of the rod would take up the jar, thus showing the knock at one point only. After the nut was taken up and everything put together again the machine ran smoothly.

A 48x24-in. slide-valve engine had a 15x48-in. air compressor built tandem to the end of the cylinder. The compressor piston rod was screwed into the elongated steam piston nut and locked with a set-screw. For some days there had been a slight knock which was getting gradually worse, especially when a heavy load was thrown on. The air and steam cylinder heads were taken off and the air piston looked as if it may have touched the head, but, although the rod was slightly loose in the nut, check marks indicated it had not turned. This was also shown by the clearance of ⅛ in., which was correct.

The heads were put on and slight adjustments made to the crank and crosshead and the machine put to work again. The knock was there as before. After a couple of days the steam-cylinder head was again taken off to make sure that the main piston nut was set up tight, which it proved to be. It was found, though, that the air piston rod was slightly loose in the threads again, but had not turned appreciably from the mark. This gave a clue to the cause of the trouble.

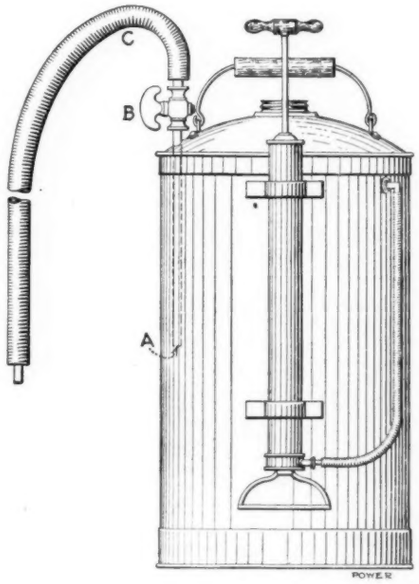
The engine was belted to a direct-current generator situated on the side opposite the crank. The heavier strain on the main bearing was on this side. There had been a slight wobble to the crankshaft for some time, but the engine ran so well that no attention was paid to it until it was proved that this side-play had increased sufficiently to take up the clearance in the air cylinder when heavily loaded. A half turn on the inside quarter-box adjusting screws stopped the noise. Closer adjustment of this box made the main bearing run warm.

T. H. HEATH.

Seattle, Wash.

Oil Can for Lifting Waste Oil

The illustration shows a can for taking up oil from places difficult of access in the usual way. The can is the ordinary galvanized, 5-gal. size and the pump is



VACUUM CAN FOR LIFTING OIL FROM INACCESSIBLE PLACES

of the bicycle variety with a leather plunger. A metal valve stem is soldered on the bottom end in place of the hose connection found on the pump. To the valve stem or check valve, is attached a small rubber hose, the other end of which is connected to the top of the can. A small pipe *A* is soldered on the top of the can, to which is attached a small petcock *B* and a piece of rubber hose *C*.

Gaskets should be placed under the caps on top of the can to make them air-tight. A few strokes of the pump removes the air from the can, whereupon, by placing the end of hose in the oil to be canned, and opening the cock, the oil flows into the can.

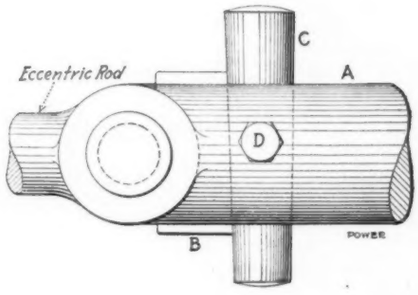
O. O. LEMON.

Bristol, Va.

Pump Detail Improvement

A portable engine turned out in large quantities has a ram-type single-acting boiler-feed pump, driven by an eccentric on the crankshaft. The ram is connected with the eccentric rod by a parallel pin secured by a washer and split pin. The ram end is forked and the eccentric rod end fits between the faces of the fork.

The pin has proved troublesome in use; every six months or thereabouts a knock developed, and to remove it the holes had



KEY AND CROSS FOR ADJUSTING WORN PIN

to be reamed and a new pin fitted. It was undesirable to enlarge the ram and shorten its stroke so as to admit of the use of a large pin. Even if this were done the trouble would still occur, though not as soon.

Means of adjustment for wear became necessary and the illustration shows how it was accomplished. The standard ram *A* was long enough outside the stuffing-box so that the existing slot had simply to be deepened and a brass block *B*, its adjusting key *C* and capscrew *D* fitted. The adjusting may be easily understood from the illustration.

Since fitting the pumps as described the manufacturers have received several letters of thanks from customers, and many of their earlier engines have been altered locally in this particular. Of course, the pump is only a minor detail, but it is careful attention to detail which frequently lands a repeat order and always satisfies customers.

A. L. HAAS.

London, England.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

High Speed Indicating

In the discussion of Mr. Clayton's paper before the A. S. M. E., reported in POWER, Aug. 13, Arthur L. Rice spoke of the difficulty of taking diagrams at high speeds. What does he call "high speed?" I indicated some of the fastest locomotives without difficulty, at over 300 r.p.m. almost daily for a long time; I have also got good diagrams at 720 r.p.m. in testing lubricants for the Standard Oil Co., and at least 25 years ago at a meeting of the Franklin Institute, got clean, practically useful diagrams at 1120 r.p.m., using a Crosby indicator which I had altered for railway work. I also "hooked on" at that speed. It was then the record, but I suppose has long ago been beaten.

ROBERT GRIMSHAW.

Dresden, Germany.

Shorter Cutoff—Greater Load

The article in POWER of Aug. 6, under the above heading, while being an explanation of the matter, will not, in my opinion, fill the bill for the engineers who are immediately concerned in this argument. In the first place, those who cannot see why shortening the cutoff on the low-pressure cylinder of a compound engine will increase its load, are not very apt to get a clear understanding of the subject from a combined indicator diagram, which in itself is apt to be a greater puzzle to them than the question of the cutoff itself.

No doubt many engineers are familiar with a combined indicator diagram and all that it stands for, but a greater number are not, and on them Mr. Low's explanation is entirely lost. The little editorial under the same heading is more likely to bring a ray of light on the subject to the engineer who does not understand it. It is rather hard to explain, and I would suggest to the subscriber who asked for the explanation (supposing him to be operating a compound engine) that he take some of his friends who are against him in the argument into his engine room and try to demonstrate to them that he is right (which he certainly is), and then analyze the reasons why it is so. Let him take a set of diagrams and get the area of them with a certain receiver pressure and figure them out before all hands, so that everybody is satisfied they are correct; then increase his receiver pressure three pounds by shortening the cutoff on the low, and then ask each one whether the load on the low-pressure will be more or less on the next diagram and then proceed to take another set of cards and show them just what the difference will be.

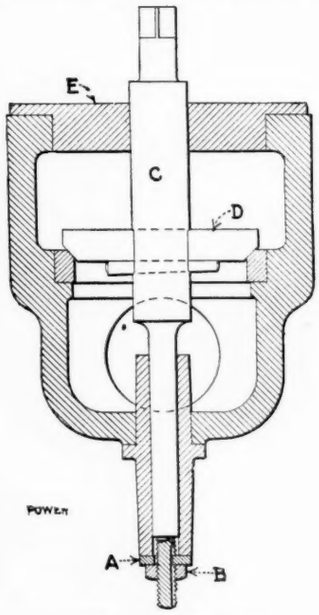
I think if he does this he will be able to show them so that they will understand the matter. It is much easier to understand a thing when you can see it done.

WILLIAM N. WING.

Brooklyn, N. Y.

Valve Seat Reamer

The valve-seat reamer shown by Mr. Benefiel, in the July 16 issue, is a good tool. We have several similar reamers for use on the valve seats of our high-pressure pumps, where the valve stems do not project through the bottom. These reamers have no bottom guides. For a gas-engine valve-seat reamer we have Mr. Benefiel's reamer "beat to a frazzle."



VALVE-SEAT REAMER

The illustration shows the advantage of our reamer over the other for use on a valve seat where the valve stem has a bottom guide. The sliding collar *A* and nut *B* on the end of the cutter spindle *C* provide means for feeding the cutter down on the seat, and prevent the cutter *D* from chattering. The spindle guide is shown at *E*.

We ream the seats lightly every time the valves are ground, and find this makes it easier to remove the hard scale that forms, and saves a lot of time in grinding.

H. H. DELBERT.

Titusville, Penn.

Mr. Greene's Noisy Heater

On page 883 of the June 18 issue, Mr. Greene states that my suggestion as to the cure for his noisy heater did not work when put to the test. I am still of the opinion, however, that, if he will make the seal deep enough, the noise will stop. The supply pipe should be run down on the outside of the heater and entered at a point on a level with the exhaust-steam inlet. This way of supplying the cold water would work best, as if steam is formed in the pipe inside the heater, it will rise to the top without interference and be replaced by water from below, no condensation taking place, no vacuum and consequently no noise.

W. T. MEINZER.

Brooklyn, N. Y.

Load on Stay-bolts

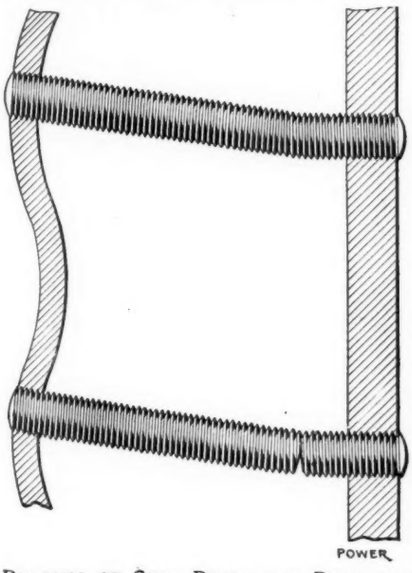
In a recent article the methods of calculating the load on a stay-bolt was given, and the result compared with the tensile strength of stay-bolt iron gave a factor of safety of eight. This being higher than the factor of safety used in some other parts of the boiler, especially the longitudinal seams, why is it used?

The factor of safety might be reduced in several ways, each open to objections. It may be reduced to that of the seams, by reducing the diameter of the bolts, but this will reduce the size of the tap, which is likely to increase the breakage of taps when motor driven, as both sheets are tapped at once with a tap long enough to reach through so that the continuous threads on the bolt will mate in both sheets without strain. Perhaps the most important point is the added strain thrown on neighboring bolts when one breaks. The pitch may be increased, but here the bulging resistance of an unstayed flat sheet is involved and the added strain on bolts near a broken one is objectionable.

Even with a factor of safety of eight stay-bolts break for several reasons. In practice, with the fire sheet about half

as thick as the wrapper sheet, the bolts almost invariably break close to the wrapper sheet and seldom against the fire sheet, and far more broken bolts are found high up toward the crown sheet than near the mud ring.

The wrapper sheet is subjected to a temperature of, say, 370 deg. F. The outer temperature of the lagging being less, the mean temperature of the plate is below 370 deg. The fire sheet is exposed to the great heat of the fire on one side and its temperature may be greatly increased if the water side is covered by scale. The expansion of the fire sheet is, therefore, considerably greater than that of the wrapper, and this relative movement of the sheets bends the bolts approximately ⅛ in. in fair sized boilers. The thicker the scale the hotter the fire sheet gets, greater expansion occurs, and



BENDING OF STAY BOLTS AND BUCKLING OF THE SHEET

the bolts are more severely bent. Both sheets are firmly held by the mud ring. The lower bolts are subjected to but little bending strain, the upper ones suffering the maximum distortion, which is why the maximum breakage is at the top, notwithstanding the greater length of bolts as the water leg widens toward the crown sheet.

As the back head is stiffer than the flue sheet, any horizontal expansion travels forward, causing greater breakage of bolts toward the front end of any horizontal row than at the back, since the movement of the sheet at that point is both upward and horizontal, a bolt being bent along the diagonal of these two movements. The amount of this bending depends upon the stiffness of various parts, such as the flue sheet, and its ability to bend between the sheets on the one hand and the expanding flues on the other. Breakage is a maximum at the upper and forward corners of the fire box.

The stiffness of a row of bolts tends to cause a slight bend or wave in the sheets to which they are attached, as shown in the illustration. If each sheet remained vertical, then the two ends of the bolts would be horizontal, but with the fire end above the outside end. This requires a bend at each sheet. The outer sheet being comparatively thick, retains practically its flat form, but the thin fire sheet takes part of the bend from the bolts. The total distortion of the bolts at the wrapper being greater than at the inside sheet causes more frequent breaking at that point than at the fire sheet, which is evident when the alternate heating and cooling of boilers in irregular service is considered.

This repeated bending, when combined with the moderate tensile stress, being the cause of practically all of the fractures found, has given rise to the vibration test for stay-bolt iron, in which a threaded bolt, while under tension, is subjected to thousands or hundreds of thousands of slight bends, the comparative number of bends or distortions representing the relative values of different irons. It has also given rise to the flexible stay-bolt, with a ball joint at the outer sheet, so that bending at this point is avoided.

E. G. MEDART.

Quincy, Ill.

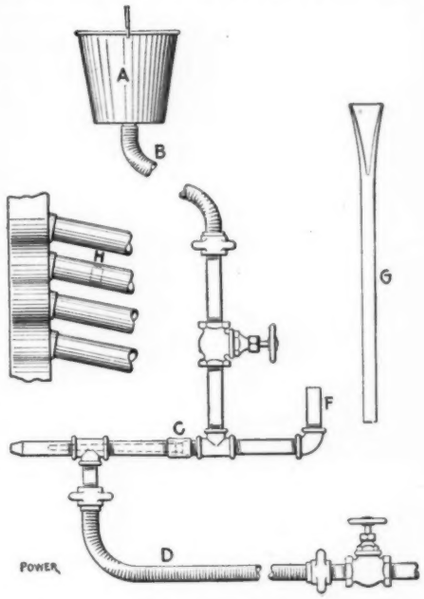
Removing a Tube Header

In the June 18 issue, A. M. Quinn gives instructions for removing a broken header from a water-tube boiler. The illustration shows a burner made of ½-in. pipe for removing a header or tube without doing any drilling or cutting.

To operate, fill the pail *A* with fuel oil and hang by a hook or other means to the crow-foot brace on the manhole. The hose *B* should be long enough to bring the burner to the opening in the header where the tube is to be heated. Place a piece of broken brick inside the tube and about 5 or 6 in. from the point where it is expanded into the header, as at *H*. Next place a piece of oily waste next to the brick in the tube. Turn on and ignite the oil from the bucket as soon as it issues from the burner nozzle *C*. Now ignite the waste and turn on the air or steam, which enters at *D*. An auxiliary air inlet is shown at *F*. If the burner is properly made and adjusted, the tube will be heated hot enough in 10 min. to be pried loose from the header with a pinch bar *G* made for the purpose. The edge of the outer hole in the header serves as a fulcrum for the bar. If the tubes removed are to be put back in the boiler, the ends require no treatment other than restoring their roundness.

The process causes no injury to the headers or tubes unless the flame is allowed to burn the metal, which can be avoided by proper care. The burner beats the hammer and chisel for this work as it is quicker and it may be also made very cheaply. It prevents the willing but careless or incompetent man from cutting the header to pieces while trying to remove a tube.

I suggested this method to the boss boiler maker of a large steel plant who



OIL BURNER OUTFIT FOR REMOVING BOILER TUBES OR HEADER

had the tubes to remove in 10 boilers. Out of the lot only two tubes were injured enough to prevent their being used again.

JOHN F. NAGLE.

Cos Cob, Conn.

Comment on a Study Question

Referring to the answer to Study Questions No. 31 in the July 2 issue, permit me to correct the statement that a direct solution cannot be obtained, as there are only four equations and five unknown quantities so that the solution must be obtained by trial.

The direct solution is obtained by subtracting 2 from the least common multiple of the divisors. For example, let x = the total number of lamps. Then x = L.C.M. of (3, 4, 5, 6) — 2 $\therefore$ $x = 60 - 2 = 58$. Suppose he had lamps enough so that he could divide them in three rows and have one left over, in four rows and have two left over, in five rows and have three left over, in six rows and four left over, in seven rows and five left over, in eight rows and six left over, in nine rows and seven left over, in ten rows and eight left over, in eleven rows and nine left over. To find the number of lamps.

L.C.M. of (3, 4, 5, 6, 7, 8, 9, 10, 11) — 2 = 27,718

Proof

$$\frac{27,718}{3} = 9239 + 1$$

$$\frac{27,718}{4} = 6929 + 2$$

$$\frac{27,718}{5} = 5543 + 3$$

$$\frac{27,718}{6} = 4619 + 4$$

$$\frac{27,718}{7} = 3959 + 5$$

$$\frac{27,718}{8} = 3464 + 6$$

$$\frac{27,718}{9} = 3079 + 7$$

$$\frac{27,718}{10} = 2771 + 8$$

$$\frac{27,718}{11} = 2519 + 9$$

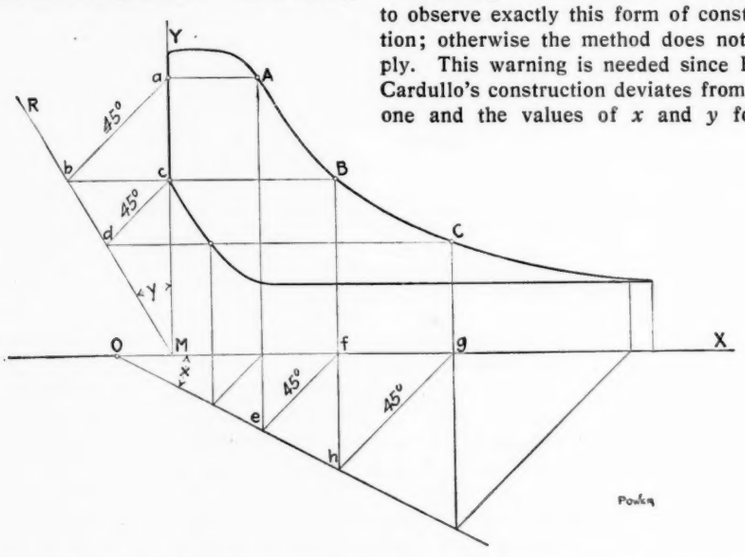
JAMES MCCLURE.

Fletcher, N. C.

Determining Clearance from Indicator Diagrams

The method of determining the clearance graphically from the indicator diagram when the curve is assumed to follow the law pv^n = constant, given on page 114 of the July 23 issue, is ingenious and useful. I developed a construction similar to Professor Cardullo's several years ago, and extended it to finding the value of n as well as the clearance.

The construction is shown in the diagram, where AC is a curve, assumed to follow the law PV_n = constant, and OX the line of zero pressure. Not knowing the zero volume axis, draw any vertical line as MY, here drawn tangent to the indicator diagram. Lay off a construction line MR at any angle y to MY, preferably making y = 30 deg. Starting with any point A on the curve, draw the lines Aa, ab, bB, as indicated and thus determine a second point B on the curve.



Repeat the same construction starting at B, using the lines Bc, cd, dC, and thus determine a third point C on the curve. Next draw vertical lines through A, B, C, and by a similar construction on the volume axis determine the points e and h. Join e and h and produce to O, which is the volume origin, and OM, the clearance desired on the indicator diagram.

This construction can be made easily and quickly and is theoretically exact. No matter what the starting point or the value of the auxiliary angle y, the origin O will always come at the same point, if the curve actually agrees with the assumed law PV^n = constant. This construction determines not only the clearance volume, but the value of n in the equation of the curve. The exact value of n is found from a rather complicated relation between angles x, y and n. A close approximation can be made by the simple relation $n = y \div x$, and as y was taken as 30 deg. to start with, it remains only to measure angle x when n can be found by division. The exponent n may be equal to, or greater or less than unity, depending on the value of x.

The theoretical error involved in the approximate determination of n is small. The approximate method becomes exact when $n = 1$. For all values of n lying between $n = 0.8$ and 1.4, the error in n is less than 1 per cent., if the angles x and y do not exceed about 40 deg. In using this construction it was recommended to use y as 30 deg., simply because this was an easy angle to draw with instruments and large enough to be measured accurately.

In finding n in this way it is necessary to observe exactly this form of construction; otherwise the method does not apply. This warning is needed since Prof. Cardullo's construction deviates from this one and the values of x and y found from his figure cannot be used in the simple way that is described here. Prof. Cardullo's method is correct for finding the clearance volume, but does not admit of using the above simple determination of n.

EDWIN H. LOCKWOOD.

New Haven, Conn.

Duchesne's Experiments on Superheat

An interesting investigation was described in the July 23 issue, under the above title, which pointed out that the indications of the mercurial thermometer, when used to determine the temperature of superheated steam, are unreliable. It is not the purpose here to comment upon the results of the investigation in so far as they affect our quantitative knowledge of superheated steam, but to call attention to the relation of these results to the use of the throttling calorimeter. Anyone who has handled this instrument to any extent will recall that the thermometer on the low-pressure side occasionally is erratic and the location of this thermometer in the steam's path seems to control its indications. This phenomenon likely is due to the two causes noted by Monsieur Duchesne to explain the discrepancies of his thermometers; namely, the low heat conductivity of superheated steam and continguous layers or strata of steam of very different temperatures. The latter cause would not be so pronounced in the restricted space of a throttling calorimeter as in a large steam pipe; nevertheless, the possibility remains, as does the need for an adequate explanation of the effect of location upon the calorimeter thermometer.

When operating from 100 lb. abs., the superheat shown by the throttling calorimeter is between zero and 115 deg. F., at a pressure between 15 and 20 lb. Duchesne's experiments do not extend to pressures as low as these, his limit being about 25 lb., under which condition an error of as much as 85 deg. C., or 153 deg. F., in the mercurial thermometer was noted, presumably at a superheat of about 300 deg. F. He says the error is augmented at the higher superheats, but, on the other hand, is higher at the lower pressures. Accordingly it may be inferred that the mercurial thermometer is untrustworthy when used to measure the superheat in a throttling calorimeter, especially if a thermometer cup is used instead of plunging the instrument directly into the stream. This accords with some observations of the writer in the use of the instrument, the conclusion being that it is better to omit the cup and use a perforated cork or wooden plug through which to pass the thermometer into the calorimeter chamber.

It requires an error of as much as 18 deg. F. in this measurement, however, to affect the result in the quality of the steam as much as 1 per cent. But it appears from Duchesne's experiments that there may be this much error. With such a possibility the refinements of stem corrections and water equivalents seem futile.

JULIAN C. SMALLWOOD.

Syracuse, N. Y.

Inquiries of General Interest

All Questions Must be Accompanied by Name and Address—Not for Publication

Clearing Storage Batteries

How can the accumulation of sediment on the bottom of a storage-battery cell be prevented from short-circuiting the plates, without lifting out the plates?

C. H. B.

The sediment falls from the sides of the plates and is deposited in ridges. When short-circuiting first becomes noticeable there is usually sufficient depth below the plates for leveling the ridges down so they will clear the plates. This is most easily done by using a rod with a right-angled foot at one end long enough to reach a little more than half way across the cell. Such a leveling hook should be entirely wood and can readily be made of white pine about ¾ in. square having the angle of the foot formed with a half lap joint held by pegs of wood.

Addition of Heat to Dry Steam

If dry steam at the pressure and temperature of saturation were inclosed in a tight vessel and superheat applied, would the pressure thereby be increased?

W. L. S.

Yes, raising the temperature of dry steam will cause it to expand if it is not confined, and if the volume is maintained constant it will cause the pressure to increase.

Pounding After Resetting Valves

After setting the valves of an engine to secure a desired form of indicator diagram, a pounding set up in the crosshead pin and crankpin which could not be removed without restoring the original valve setting. What can be done to get good diagrams without the pounding?

B. N.

Undoubtedly the crankpin and crosshead pin are worn out of round into forms peculiar to the former load, point of cutoff and compression. Changing the cutoff or compression to different points of the stroke causes distribution of pressure on the partly worn pins to be made to new places which results in pounding caused in the same manner as is often the case for a change of load. Pounding usually may be obviated for any particular load by taking up the brasses and making the desired valve adjustments gradually. By continuing the operations only as fast as the pounding can be removed, the desired adjustment of valves should be secured after a few days running unlss the pins are so worn as to require re-turning.

Designing Girth Seams

In designing the girth seams of horizontal return-tubular boilers, what allowance, if any, is made for the reduction of effective cross-sectional area of the shell due to the presence of the tubes?

H. C.

Generally no such allowance is made, as in most boilers a considerable portion of the cross-sectional area above the tubes has no reduction of area, and parts of some of the girth seams are strained nearly as much as if no tubes were present. For practical considerations all girth seams of a boiler are usually made with the same size and pitch of rivets, employing the proportions suitable for resisting the greatest strain likely to come on any part of any girth seam.

Steam Drum vs. Steam Dome

Will the use of a steam drum on a boiler be as beneficial as equal steam space in a boiler dome, and if so, what is the best method of placing the inlet and outlet conections of a drum?

L. D.

A steam drum is fully as advantageous as a dome in affording steam room, and besides dispensing with expensive construction, eliminating a dome permits better and safer boiler construction. A good way to connect a steam drum of moderate length is by a saddle flange inlet placed in the middle of its length for connection to a flanged steam nozzle on top of the boiler, with a similar outlet flange in the opposite side of the drum.

Patching a Girth Seam

How is a patch applied to the girth seam of a boiler in a place which shows fire cracks at the rivets?

F. M.

Both sheets forming the girth joint have to be cut away and several girth-joint rivets removed on each side of the hole so made, for inserting a soft patch piece which will be inside of the outer course and outside of the inner course of the shell. The patch piece is jogged and scarfed where it comes between the shell plates, forming three thicknesses, which are drawn together by rivets inserted to re-form the ends of the original girth joint. The hole and the patch piece are laid out with rounded corners and so as to give good calking pitch of rivets and have all calking done from the outside of the boiler.

Flush Ends vs. Smoke Extension

What are the advantages of return-tubular boilers having flush front ends as compared with those having front ends extended?

J. P.

For settings with flush fronts, boilers with flush front ends are preferable, as serious leakage of heated gases direct from the furnace to the smoke connection is liable to occur from failure of fire-door arches, for when this happens in case of a boiler having extended end the lower part of the smoke connection is liable to be burned off; but when the boiler has a half flush front, with its smoke connection extending forward of the main front there can be no leakage of draft direct from the fire to the smoke connection and consequently no waste of furnace heat from lowering of the fire-door arch. The latter form of smoke connection has the disadvantage, however, of offering some obstruction to firing unless a boiler is set high enough or has the smoke extension beveled backward so as not to be in the way of the fireman.

Relative Heat Under a Boiler

With the ordinary proportions of furnaces and settings, which is the hotter place under a horizontal return-tubular boiler, immediately over the grates or over the bridge-wall?

L. J. D.

Over the bridge-wall.

Boiler Efficiency

What is the efficiency of a steam boiler and how is it estimated?

J. T.

The efficiency is the ratio between the heat units utilized in producing steam and the heat units contained in the fuel actually burned, and is therefore expressed by the fraction:

$$\frac{\textit{Heat absorbed per lb. of combustible}}{\textit{Calorific value of 1 lb. of combustible}}$$

The numerator would be the equivalent evaporation per pound of combustible from and at 212 deg. F. multiplied by 970.4 (the heat of vaporization, or latent heat of steam at 212 deg.). The denominator is taken as

$$14{,}600\,C + 62{,}000\left(H - \frac{O}{8}\right) + 4000\,S$$

in which C, H, O and S are the percentages of carbon, hydrogen, oxygen and sulphur, respectively, as determined by an ultimate analysis.

Study Questions

This Week's Questions
Last Week's Answers

(91) What is the total difference in pressure when a steam gage indicates 175 lb. and a vacuum gage 26 in. of mercury, if the atmospheric pressure is 14.7 lb.

(92) Two repair men are sent from a shop to fix an engine in a plant 12 miles away. *A* has a bicycle and agrees to let *B* ride it for alternate miles. *A* starts on the wheel and *B* on foot. At the end of the first mile *A* leaves the wheel for *B* and continues walking and when *B* reaches the wheel he rides for a mile and so on. Which reaches the destination first and how long does it take him if both ride at the rate of eight miles an hour and walk at the rate of four miles an hour?

(93) What is the weight of a wooden pipe 16 ft. long, 3½ ft. in external diameter, 9 in. thick, if the timber weighs 35 lb. per cubic foot?

(94) At what speed in revolutions per minute must an 8-pole generator be driven to give alternating current at 60 cycles per second?

(95) What are the acute angles in degrees, minutes and seconds of a right-angled triangle having a base of 35 in. and an altitude of 28 in.?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

(86) According to the Law of Charles, the volume of a gas under constant pressure, or the pressure of a gas at constant volume, varies as the absolute temperature. Absolute zero is 461 deg. below 0 deg. F. Then,

$$\frac{v_1}{v_2} = \frac{t_1}{t_2}$$

where

v_1 = Initial volume = 10 cu.ft.;
v_2 = Final volume;
t_1 = Initial absolute temperature = 32 + 461 = 493 deg. F.;
t_2 = Final absolute temperature = 212 + 461 = 673 deg. F.

Hence

$$v_2 = \frac{v_1 t_2}{t_1} = \frac{10 \times 673}{493} = 13.65 \text{ cu.ft.}$$

(87) Water weighs 62½ lb. per cu.ft. Then two tons is

$$\frac{2 \times 2000}{62.5} = 64 \text{ cu.ft.}$$

The area of the bottom of the tank will be

$$6 \times 4\tfrac{1}{2} = 27 \text{ sq.ft.}$$

Hence the inside height of the tank must be

$$\tfrac{64}{27} + \tfrac{1}{2} = 2.87 \text{ ft.}$$

The area of sheet lead required will be

$$\begin{aligned} 6 \times 4.5 &= 27 \\ 2 \times 6 \times 2.87 &= 34.44 \\ 2 \times 4.5 \times 2.87 &= 25.83 \\ &\hline \\ &87.27 \text{ sq.ft.} \end{aligned}$$

or

$$87.27 \times 144 = 12{,}566.9 \text{ sq.in.}$$

and the volume of lead

$$12{,}566.9 \times 0.125 = 1570.86 \text{ cu.in.}$$

Lead weighs 0.4106 lb. per cu.in., hence the weight required will be

$$1570.86 \times 0.4106 = 645 \text{ lb.}$$

(88) For the pump to discharge 400 gal. per min. it must be driven at

$$\frac{400}{3.2} = 125 \text{ r.p.m.}$$

The shaft speed will be inversely as the pulley diameters, then the line-shaft pulley diameter D may be found from the relation

$$\frac{D}{18} = \frac{125}{80} \text{ or } D = \frac{125 \times 18}{80} = 28\tfrac{1}{8} \text{ in.}$$

(89) A British thermal unit is defined as the amount of heat required to raise 1 lb. of water 1 deg. F. Then to raise 1 lb. from 50 to 120 deg. F. would require

$$1 \times (120 - 50) = 70 \text{ B.t.u.}$$

The mechanical equivalent of heat is

$$1 \text{ B.t.u.} = 778 \text{ ft.-lb.}$$

Then

$$70 \text{ B.t.u.} = 778 \times 70 = 54{,}460 \text{ ft.-lb.}$$

(90) In the formula for horsepower

$$Hp. = \frac{plan}{33{,}000}$$

where

p = Mean effective pressure in lb.;
l = Length of stroke in ft.;
a = Area of cylinder in sq.in.;
n = Number of strokes.

All of the quantities are known except a. Substituting

$$100 = \frac{36 \times 3.5 \times a \times 160}{33{,}000}$$

or

$$a = \frac{33{,}000 \times 100}{36 \times 3.5 \times 160} = \frac{3{,}300{,}000}{20{,}160}$$

$$= 163.69 \text{ sq.in.}$$

Since the area of a circle is

$$A = \tfrac{1}{4} \pi D^2$$

where

$\pi = 3.1416$

D = Diameter of the circle

$$163.69 = \frac{3.1416}{4} \times D^2$$

$$D^2 = \frac{163.69}{0.7854} = 208.416$$

$$D = 14.436 \text{ in.}$$

Over the Spillway

A large collection of the most eminent foreheads from the four quarters of Mother Earth recently gathered in New York for the International Congress for Testing Materials. There were princes, ministers, privy councillors, scientists, savants and royal and loyal Americans, all paying homage to old Father Science. It is their work which is making our jobs safer from fire and disaster, and they are spending $250,000 on this trip that they may learn more to tell more. Many things must be done in the rough before we get the finished product to warm up for operation, and these men in a quiet way are paving the broad and safe road for us.

Did you read Danny Hogan's "Daly and Doolin" story on page 366 of the Sept. 3 issue? Danny was right on the spot with a few predigested crumbs of thought on the boiler-rules situation and had a fine kernel of wisdom on "the mad desoire of engineers to monkey wid safety valves."

C. O'Two, says the *Fluegas Recorder*, is the new efficiency engineer in the Economy lighting station.

In the lively town of Brockton, Mass., lives a real live Italian countess who would rather wed a live-wire electrician than inherit a quarter million dollars. "There's nothing could buy my Andy!" says she. Now all you other "Andy" boys, buck up! In these days of high construction there is nothing out of reach of any ambitious Andy.

Marcel Meyer, chief engineer of the State Light & Power Electrical Station, a municipal plant in that dear Paris, has returned to La Belle France. Marcel is disappointed in Chicago, St. Louis and Buffalo. He seems to feel that America can't learn him nothing nohow. Another marcel-wave of disapproval for that poor America.

Thomas Fleming Day, a Buffalo yachtsman, has started for St. Petersburg in a 30-ft. boat having a two-cylinder, 16-hp. engine, and with 1200 gal. of fuel in the tanks. "Some Day," as the song goes. Here's hoping that Tommy does not drift across St. Peter before he reaches the "burg."

A politician had his greenhorn cousin appointed a smoke inspector, says the *Kansas City Journal*. The "inspector's" first monthly report read as follows:

"I certify that I have inspected the smoke of this city for the thirty days past. I find plenty of smoke and apparently of good quality. Respectfully submitted."

New Bundy Steam Trap

This is an improved form, but the same general principle in the construction and mechanism has been maintained, and the objectionable feature of the original trap, leaking trunnion joints, has been eliminated. The manufacturers state that there will be no trouble with packing or leaking joints in the new trap, as it is designed to be steam- and water-tight under all conditions and require no attention.

In the new trap the capacities have been increased as the trap works up to a much higher pressure which gives it a

FIG. 1. NEW BUNDY RETURN TRAP

larger range of usefulness. A side view of a return trap is shown in Fig. 1 and an end view of a tank trap in Fig. 2. A view of the new design of yoke is shown in Fig. 3. Connection is made from one bearing end to the bowl chamber; the other bearing end is connected to the cast outlet chamber.

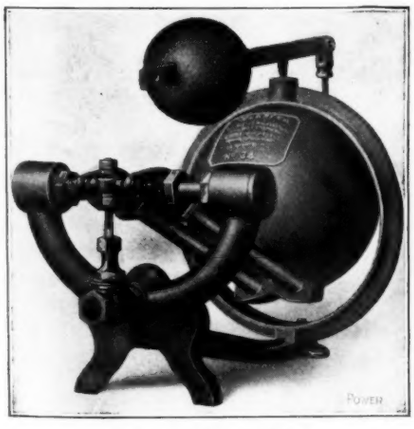


FIG. 2. TANK TRAP

The receiving bowl is cast round and of uniform thickness throughout, which, with its shape, offers a high factor of safety for operating under high pressure. The receiving bowl of the return trap has its steam inlet passage cast on the inside, Fig. 4, which eliminates the bent tube found in the old type of bowl.

In operation, condensation collects in the receiving bowl, which when filled tilts and opens the steam valve, admit-

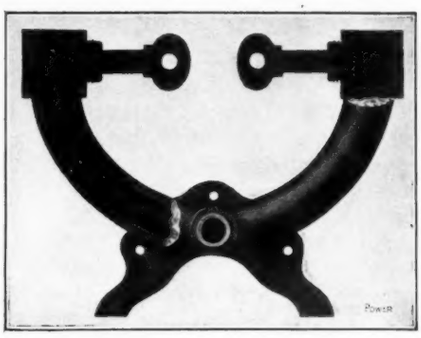


FIG. 3. THE NEW DESIGN OF YOKE

ting steam under boiler pressure to the bowl. The pressure in the trap and

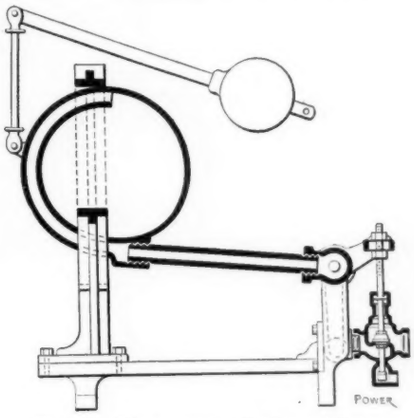


FIG. 4. SECTION OF RETURN TRAP

boiler is thus equalized and when placed above the boiler the water will flow into it by gravity. When empty, the receiving bowl tips back to its filling position and is ready for the next charge.

This trap is manufactured by the Nashua Machine Co., 127 Federal St., Boston, Mass.

Diesel Engine Ship Makes Good Record

The first of the Hamburg-American line's new oil-burning vessels to arrive at New Orleans was the "Christian X," which reached port on Sept. 7 from Hamburg after a successful voyage. It is of the new "stackless" type, equipped with Diesel engines using a low-grade of petroleum oil.

The "Christian X" left Hamburg on July 22, and on her first day, with good weather, made an average of 11½ nautical miles an hour. Later, under heavy weather and storm conditions, her general average for the trip was 11.01 nautical miles an hour. She spent four days in port at Havana and eight at Vera Cruz, and consumed 710 tons of oil. This is a creditable record for a vessel of this size driven by oil engines, for the "Christian X" is 370 ft. long by 53 ft. beam and, loaded, her tonnage is 9800. She has two heavy-duty engines, which can be controlled by a single lever, and reversed from full speed ahead to full speed astern in less than nine seconds.

The exhaust gases, after being cooled, pass out 49 ft. above the deck through the after mast, which is hollow.

Pension Plan for Employees

A pension plan has been announced by the General Electric Co. for its large force of employees. The pension will be 1 per cent. of the applicant's average yearly wages for the 10 years preceding retirement, multiplied by the number of years employed, and will be paid to men of 70 and women of 60, who have been 20 years or more in the company's service. Also provision is made for men of 65 and women of 55 who are incapacitated for further work.

The International Association for Testing Materials

The Sixth Congress of the International Association for Testing Materials, held at the Engineering Societies Building, New York, during the week commencing Sept. 2, called together between 800 and 900 delegates from all over the world, including many whose names are prominent in engineering, metallurgical and industrial circles.

Monday was devoted to registration and committee meetings, with a reception in the evening under the auspices of the American Society for Testing Materials, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers and the American Institute of Mining Engineers.

On Tuesday morning the president and members of the council of the International Association for Testing Materials received formally the official delegates from governments, and at 10 o'clock the opening session of the congress was held. Addresses of welcome were delivered by Robert W. Hunt, president of the American Society for Testing Materials, by Gen. William H. Bixby, chief of engineers of the United States Army, on behalf of the President of the United States, John A. Dix, governor, on behalf of the State of New York, William A. Prendergast, controller, on behalf of the mayor of the City of New York, and Henry M. Howe, acting president of the International Association, delivered his presidential address.

In the afternoon the various sections held their professional sessions, and in the evening an opportunity was given to visit the New York Public Library under the guidance of the city officials.

Wednesday forenoon was devoted to professional sessions, and in the afternoon the party was taken by steamer to

the United States Military Academy at West Point, returning to New York late in the evening.

On Thursday sessions were held both forenoon and afternoon, and in the evening a reception was tendered to the foreign delegates and foreign members by the American Society of Civil Engineers at its house. During the evening, Alfred D. Flinn, member of the American Society of Civil Engineers, gave an illustrated lecture on the engineering activities of New York City.

On Friday the entire day was devoted to professional sessions, and the evening left free.

On Saturday the closing session of the Congress was held in the forenoon. In the afternoon a reception was tendered to the members of congresses of testing materials and of applied chemistry, which was also in session in New York at the same time, by the Museum of Natural History, and in the evening by the Metropolitan Museum of Art.

Following the congress a number of tours have been arranged, in which many of the delegates will participate.

Second Annual Meeting, Institute of Operating Engineers

The second annual meeting of the Institute of Operating Engineers, held in the Engineering Societies Building, 29 West Thirty-ninth St., New York City, Sept. 6 and 7, was highly successful.

Friday morning, C. A. Prosser, secretary of the National Society for the Promotion of Industrial Education, made the welcoming address which was responded to by President J. C. Jurgensen of the institute. After a reading of a summary of the minutes of the last annual meeting, the various committees were appointed. The report of the finance committee was then read, which showed the institute to be in favorable circumstances financially.

At 2:15 p.m. the professional session opened and continued throughout the afternoon. This session was very well attended and the papers read were received with much interest.

Alexander Gordon, chief engineer of the Boston Store, Providence, R. I., read a paper on the subject of the use of tungsten lamps as a commendably practical way of reducing the load on an overloaded plant; an abstract of which appears elsewhere in this issue. A paper by Robert H. Karl, chief erecting engineer for the Anheuser-Busch Brewing Co., of St. Louis, discussed the effect of varying the suction pressure on the economy of ammonia compressor machines. Interesting discussion led by H. W. Geare followed the reading. Mr. Karl's paper will appear in an early issue.

"Keeping Tabs in Industrial Plants" was the subject of a paper by Peter Lunbeby, which contained many excellent suggestions for establishing a system of record keeping, and will appear soon in POWER. Other interesting papers covered: "The Steam Engine Indicator," by C. S. Foster; "Steam in a Sugar Cane Factory," by W. A. T. Willink; "Watertown Engine Improved by Extra Exhaust Valve," by Wendolein Senge, and "Electric Drive versus Steam Drive," by J. F. Carman.

The commencement exercises, held Friday evening, were opened by Prof. Maxwell, of Pratt Institute, as Dr. Richards, Director of Cooper Union, who was to address the institute could not attend. Prof. Maxwell in his address on "Industrial Education and Its Relation to the Operating Engineer," emphasized the great advantage of the engineering student "finding himself" before he went too far in such studies, as only too often the student discovers, when too late, his inaptitude for such work. In this connection he condemned the proposed six-year college-engineering course. This course as proposed would require two years of practical work after the studies were completed. Prof. Maxwell contended that the practical work should precede the studies to determine the student's dormant qualifications as an engineer.

President Jurgensen presented diplomas to the class graduating as master operating engineers. Those honored were: Michael Furlong, James Fagan, John T. McDonough, John McGinley, Alonzo McLaughlin, George Pattberg and Harry W. Wright. The valedictory oration was made by Mr. Furlong.

The business meeting was called to order at 10 a.m., Saturday. In the afternoon the following officers were elected:

President, F. L. Johnson, chief of construction department, Edison Electric Illuminating Co., Brooklyn (one-year term); vice-president and director department of vocational statistics and employment, V. L. Rupp, chief engineer, Williamson Trade School, Williamson, Penn. (three-year term); vice-president and director of department branches and meetings, William J. Fair, chief engineer, Murray Hill Hotel, New York City (two-year term); vice-president and director of department of industrial education and training, William J. Freer, chief engineer, Citizens Central Bank Building, New York (one-year term). (Mr. Freer had been fiilling out the unexpired term of J. G. Ould, deceased); treasurer, W. P. F. Hill, chief engineer of Woman's Hospital, New York, reëlected (one-year term); commissioners at large, Lawrence Honmiller (one year), Darrow Sage (two years), Robert Langlotz (three years); commissioners, District No. 1, J. L. MacVicar, chief engineer, Boston City Hospital, Boston (three years) (reëlected); District No. 2, W. A. T. Willink, erecting and designing engineer, Arbuckle Brothers, New York (three years); District No. 3, D. B. Heilman, inspector, Philadelphia & Reading Ry. Co., Reading. Penn. (three years) (reëlected).

SOCIETY NOTES

Minneapolis Association No. 2, N. A. S. E., is arranging a "get together and booster" meeting for its last meeting in September, on Saturday evening the twenty-eighth. J. F. Flather, professor of mechanical engineering, University of Minnesota, will be among the speakers. It is the association's desire that every old member and every engineer interested in the work will be present and "get together" and boost the purpose and principles of the N. A. S. E.

Members of the American Society of Mechanical Engineers are urged to notify the secretary if there is any possibility of their taking part in the joint meeting with the Verein Deutscher Ingenieure at Leipzig in June of next year. It is the wish of the German society that as many representative American engineers shall accept the invitation as possible, and the invitation is broad enough to include not only the present members of the American society, but to permit those members to bring with them desirable guests. It will greatly facilitate the work of the committee on arrangements if they can have an early indication of the number for which they will have to provide.

PERSONAL

Thomas L. Delahaunty, who succeeds the late James J. Waters as corresponding and financial secretary and business manager of Marine Engineers' Beneficial Association No. 33, was born in Charleston, S. C., in 1865. Obtaining his first license in 1889, he sailed as an engineer in the old Pacific mail steamer "City of Para" between New York and Colon, going from there to the old Rio Line and serving as an engineer on all that line's steamers. He was afterward chief engineer in the Ward and Mallory lines. Shortly after the New York municipal ferries were inaugurated, Mr. Delahaunty was employed by the city. He resigned later and for the past four years has been chief engineer of the American Mail Steamship Co. on the steamers "Admiral Schley" and "Admiral Dewey." Mr. Delahaunty has been an enthusiastic member of the marine engineers' association ever since he obtained his original license as a marine engineer, and he was a representative to the thirty-fifth, thirty-sixth and thirty-seventh national conventions. He brings to his new position, to which he was unanimously elected by his fellow-members, a wide experience in matters affecting marine engineering.